User's Guide

Snap-Master for FactorySuite

Data Acquisition Module
Waveform Analyzer Module
Frequency Analyzer Module

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Table of Contents

Overview

Chapter 1. Getting Started

1.1. Welcome! **1-1**
Sample Instruments 1-1
1.2. Technical Support **1-3**
Registration 1-3
Customer Support 1-3
Where To Go For Help 1-3
When You Call For Support 1-4
What Is Technical Support? 1-4
Extended Support Programs 1-5
1.3. System Requirements **1-5**
1.4. Installing Snap-Master **1-6**
1.5. Computer Configuration **1-6**
Windows 3.1 1-6
386 Enhanced Mode 1-7
Standard Mode 1-8
Windows 95 1-8
Windows NT 1-8
Using Disk Compression or Caching Software 1-8
1.6. Start Using Snap-Master **1-8**

Chapter 2. Snap-Master Basics

2.1. Workspace **2-1**
Command Bar 2-1
Status Bar 2-2
Toolbox 2-2
Instrument Window 2-3
Comment Field 2-3
File Menu 2-4
Element Menu 2-4
View Menu 2-6
Settings Menu 2-6
Start! Menu 2-9
Window Menu 2-9
Help Menu 2-9

2.2. Elements **2-10**
Overview of Elements 2-10
Input Elements 2-11
Analysis Elements 2-11
Output Elements 2-12
Menus And Command Bar 2-12
File Menu 2-13
Edit Menu 2-14
View Menu 2-14
2.3. Instruments **2-15**
Instrument Construction Guidelines 2-15
Frame Characteristics 2-16
2.4. Tutorial: Creating Your First Instrument **2-16**
Creating a New Instrument 2-17
Placing and Connecting the Elements 2-18
Running the Instrument 2-19
2.5. A/D Demo Element **2-20**
A/D Demo Settings 2-20
2.6. Tutorial: Changing A/D Demo Parameters **2-21**
Changing the Sample Rate 2-21
Changing the Frame Length 2-22
Stopping the Instrument Automatically 2-22
Running the Instrument 2-22

Chapter 3. Display

3.1. Display Window **3-1**
Command Bar 3-2
Scroll Bar 3-2
3.2. Plot Types **3-3**
Default Plot Templates 3-3
Y vs. T Plots 3-3
Strip Charts 3-9
Frequency Plots (Mag vs. F, Phase vs. F) 3-9
Y vs. X, Scatter Plots 3-9
Digital Meters 3-10
Indicators 3-12
Bar Meters 3-12
Dial Meters 3-14
Histogram Plots 3-15
3.3. Menu Commands **3-16**
File Menu 3-16
Edit Menu 3-17
View Menu 3-17
Settings Menu 3-20
Start Menu 3-22
Layout Menu 3-23
Cursor Menu 3-25

3.4. Tutorial: Changing the Display Settings 3-28
Changing Line Colors and Styles 3-28
Deleting and Inserting Plots 3-30
Overplotting Multiple Channels 3-31
Strip-Charts and Y-X Plots 3-32
Changing Other Plot Components 3-34
3.5. Tutorial: Using Display Pages 3-36
Moving a Plot To A New Display Page 3-36
Changing The Display Page Title 3-36
Changing The Display Page Rows and Columns 3-37
Running the Instrument 3-37
3.6. Tutorial: Using Cursors And Markers 3-38
Placing A Cursor 3-38
Moving The Cursor 3-39
Finding The Slope Between Two Points 3-39
Using Linked Cursors 3-40

Chapter 4. Disk I/O

4.1. Data File Overview 4-1
Native Data Files 4-2
Generic Data Files 4-2
Data File Naming Conventions 4-3
4.2. Disk In 4-4
Disk In Settings 4-4
4.3. Disk Out 4-8
Disk Out Settings 4-8
Overwriting Data Files 4-11
4.4. Tutorial: Saving Data To Disk 4-12
Building the Instrument 4-12
Specifying The Data File Name 4-12
Running The Instrument 4-13
4.5. Tutorial: Reading Data From Disk 4-14
Building the Instrument 4-14
Specifying The Data File Name 4-14
Running The Instrument 4-15
4.6. Data File Formats 4-15
Data File Structure 4-15
Header Information 4-15
Exponential Data File Format 4-17
Standard Binary Data File Format 4-19
Fast Binary Data File Format 4-20
Comma Separated Variable Data File Format 4-21
ASCII Plotter Data File Format 4-21
Binary Plotter Data File Format 4-22

Chapter 5. Wave Generator

Command Bar 5-1
Table Columns 5-2
5.1. Waveforms 5-2
Amplitude Modulation 5-3
Bessel 5-3
Constant 5-4
Cosine And Sine 5-4
Frequency Modulation 5-5
Ramp 5-5
Sawtooth 5-6
Sinc 5-6
Square 5-7
Trapezoid 5-7
Triangle 5-8
White Noise 5-8
5.2. Menu Commands 5-9
Edit Menu 5-9
Settings Menu 5-9
5.3. Tutorial: Creating A Sine Wave 5-10
Building the Instrument 5-10
Setting Up A Waveform 5-11
Running the Instrument 5-12
5.4. Tutorial: Using Multiple Stages 5-13
Creating Waveform Stages 5-13
Configuring Each Waveform Stage 5-14
Running the Instrument 5-16

Chapter 6. Dynamic Data Exchange

Clipboard 6-1
Dynamic Data Exchange (DDE) 6-1
DDE And Snap-Master 6-3
DDE And Other Applications 6-5
6.1. DDE In 6-5
Command Bar 6-5
Table Columns 6-6
Menu Commands 6-6
Settings Menu 6-7
6.2. DDE Out 6-8
6.3. Tutorial: Receiving Data In From A Local Spreadsheet 6-11
Building the Instrument 6-11
Configuring the DDE Conversation 6-12
Setting The DDE In Frame Settings 6-12
Setting Up The DDE In Channel 6-13
Running the Instrument 6-14
6.4. Tutorial: Sending Data Out To A Local Spreadsheet 6-14
Building the Instrument 6-14
Configuring the A/D Demo 6-15
Copying the DDE Link 6-15
Running the Instrument 6-16

6.5. Tutorial: Using Block Mode 6-17
Modifying the Instrument 6-17
Copying a DDE Data Block 6-17
Running the Instrument 6-18
6.6. Tutorial: Sending Data To A Spreadsheet Over NetDDE 6-18
Setting Up The NetDDE Server 6-18
Setting Up The NetDDE Client 6-20
Running the Instrument 6-20
6.7. Tutorial: Sending Data To Snap-Master Over NetDDE 6-21
Building the DDE Client Instrument 6-21
Configuring the DDE Conversation 6-21
Setting Up The DDE In Channels 6-22
Running the Instrument 6-22

Data Acquisition

Chapter 7. Sensors & Signal Conditioning

7.1. Sensor Database 7-1
Sensor Database Files 7-2
Input And Output Values And Units 7-2
Sensor Assignments 7-3
Table Columns 7-3
7.2. Sensor Menu Commands 7-4
View Menu 7-4
Settings Menu 7-4
7.3. Signal Conditioning 7-7
7.4. Tutorial: Adding A Sensor To The Sensor Database 7-8
Building the Instrument 7-8
Inserting A New Sensor 7-8
7.5. Tutorial: Using The Sensor Element 7-10
Building The Instrument 7-10
Assigning a Sensor To An Input Channel 7-11
Running The Instrument 7-11
7.6. Tutorial: Updating a Sensor's Calibration History 7-12
7.7. Tutorial: Additional Sensor Database Hints 7-13
Copying An Existing Sensor 7-13
Using The Sensor To Assign Channel Labels 7-13

Chapter 8. Data Acquisition

8.1. Analog Input (A/D) 8-1
Command Bar 8-2
Table Columns 8-2
Dialog Interface 8-3
8.2. Menu Commands 8-4
Edit Menu 8-4
Settings Menu 8-4
Device Menu 8-11
8.3. Digital In 8-13
Digital In Settings 8-13

8.4. Tutorial: Acquiring Analog Data 8-13
Building the Instrument 8-13
Configuring the A/D Element 8-14
Running the Instrument 8-15
8.5. Tutorial: Using Triggers to Start Acquisition 8-15
Setting Up A Trigger 8-15
Running the Instrument 8-16
8.6. Tutorial: Acquiring From Multiple Devices 8-17
Building the Instrument 8-17
Configuring the Input Elements 8-18
Saving Data From Only One Channel 8-20
Running The Instrument 8-20
8.7. Tutorial: Acquiring Digital Data 8-21
Building the Instrument 8-21
Configuring the Digital In Element 8-21
Running the Instrument 8-22

Chapter 9. Counter Timer

Special Wiring Instructions 9-1
9.1. Counter Timer Input 9-2
9513 Setup 9-2
9.2. Tutorial: Measuring Pulse Counts 9-6
Building the Instrument 9-6
Configuring A Counter For Pulse Counting 9-7
Configuring A Counter As An Internal Pacer 9-9
Signal Connections 9-9
Running The Instrument 9-10
9.3. Tutorial: Frequency Measurements 9-10
Configuring A Counter To Measure Frequency 9-10
Signal Connections 9-11
Running The Instrument 9-12
Alternate Frequency Measurement Method 9-12
9.4. Overview Of The 9513 9-14
Source, Gate, and Output 9-14
Load and Hold Registers 9-15
Terminal Count (T/C) 9-15
Modes 9-15

Chapter 10. RS-232

Answers To Commonly Asked Questions 10-1
10.1. RS-232 Settings 10-2
String Assignments 10-3
Configuration 10-7
10.2. Tutorial: Writing Example RS-232 Strings 10-8

Chapter 11. Data Output

11.1. Analog Output (D/A) **11-1**
D/A Settings 11-1
11.2. Digital Out **11-3**
11.3. Tutorial: Outputting Analog Data **11-4**
Building the Instrument 11-4
Configuring the A/D Demo 11-5
Configuring the A/D Hardware 11-5
Configuring the D/A 11-6
Running the Instrument 11-7
11.4. Tutorial: Outputting Digital Data **11-7**
Building the Instrument 11-7
Configuring the Digital Out Element 11-8
Running the Instrument 11-8

Data Analysis

Chapter 12. Analysis and Frequency Analysis

Analysis 12-1
Frequency Analysis 12-1
Command Bar 12-2
Table Columns 12-2
Quick Function Reference 12-3
12.1. Menu Commands **12-4**
File Menu 12-4
Builder Menu 12-5
Settings Menu 12-7
12.2. Functions **12-11**
Arithmetic Functions 12-12
Trigonometric Functions 12-13
Calculus Functions 12-15
Statistical Functions 12-16
Logical Functions 12-18
Filters 12-20
Time Functions 12-22
Data Ranges 12-22
Miscellaneous Functions 12-25
12.3. Equation Syntax **12-26**
Equation Format 12-27
User Defined Functions 12-27
12.4. Tutorial: Adding Two Channels **12-28**
Building the Instrument 12-28
Building The Equation 12-29
Running the Instrument 12-31
12.5. Tutorial: Performing A Block Average **12-32**
Building The Equation 12-32
Running The Instrument 12-34
12.6. Tutorial: Finding When An Event Occurs **12-34**
Building The Equation 12-34
Running The Instrument 12-36

12.7. Tutorial: Integrating Over A Specific Range Of Data 12-37
Building The Equation 12-37
Running The Instrument 12-39
12.8. Tutorial: Defining Your Own Functions 12-40
Defining A New Function 12-40
Calling The Function In An Equation 12-41
Running the Instrument 12-42

Chapter 13. Command

Command Bar 13-1
Equation Table Columns 13-1
13.1. Menu Commands 13-2
View 13-2
Settings 13-2
13.2. Command Equations 13-3
Subroutines 13-4
Result Channels and State Variables 13-4
Comparisons 13-5
Logical Functions 13-6
Actions 13-7
Case Statements 13-9
13.3. Tutorial: Creating A Trigger To Stop 13-9
Building the Instrument 13-9
Writing A Command Routine 13-10
Turning Off Status Messages For The Instrument 13-11
Running The Instrument 13-11
13.4. Tutorial: Subroutines and State Variables 13-12
Defining The Equation Table 13-12
Running The Instrument 13-14
13.5. Tutorial: Automatically Starting Another Instrument 13-15
Building the Second Instrument 13-15
Updating The Command Routine 13-16
Running The Instrument 13-16

Chapter 14. FFT

Command Bar 14-1
Table Columns 14-1
14.1. Menu Commands 14-3
Builder 14-3
Settings 14-5
14.2. Functions 14-6
Summary 14-6
Forward FFT 14-7
Inverse FFT 14-7
Auto Power Spectrum 14-7
Auto Power Spectral Density 14-7
Cross Power Spectrum 14-8
Cross Power Spectral Density 14-8
Coherence Function 14-8
Coherent Output Power 14-9
Transfer Function 14-9

Compliance 14-10
Impedance 14-10
Dynamic Compressibility 14-10
Bulk Modulus 14-10
Admittance 14-10
Dynamic Flexibility 14-10
Mobility 14-11
Dynamic Accelerance 14-11
Dynamic Stiffness 14-11
Transmissibility 14-11
Dynamic Inertia 14-11
14.3. Window Types 14-11
Selecting A Window Type 14-12
Window Width Response 14-13
Window Effects Illustrated 14-14
Blackman 14-16
Blackman-Harris 14-17
Bohman 14-17
Cauchy 14-17
Cosine 4th Power 14-18
Cosine Tapered 14-18
Exact Blackman 14-18
Exponential 14-19
Extended Cosine Bell 14-19
Flat Top 14-20
Gaussian 14-20
Half Cycle Sine 14-20
Hamming 14-21
Hann 14-21
Hanning-Poisson 14-21
Kaiser-Bessel 14-22
Parabolic 14-22
Parzen 14-22
Poisson 14-23
Rectangular 14-23
Riemann 14-23
Sine 3rd Power 14-24
Triangular 14-24
14.4. Window Width 14-24
Available Widths 14-25
Frequency Resolution and Spectral Lines 14-25
Forcing Periodicity 14-25
14.5. Tutorial: Performing a Forward FFT 14-26
Building the Instrument 14-26
Configuring the A/D Demo Element 14-27
Calculating The Forward FFT 14-27
Running The Instrument 14-29
14.6. Tutorial: Performing an Inverse FFT 14-29
Calculating An Inverse FFT 14-29
Running the Instrument 14-31
14.7. Tutorial: Cross Power Spectrum 14-31
Adding The Second A/D Demo 14-31
Calculating the Cross Power Spectrum 14-32
Running the Instrument 14-33

14.8. Tutorial: Transfer and Coherence Functions 14-34
Calculating The Transfer Function 14-34
Calculating The Coherence Function 14-35
Running the Instrument 14-36

Chapter 15. Utility Elements

15.1. Relay 15-1
Auto Toggle Settings 15-2
15.2. Tutorial: Relay 15-4
Building the Instrument 15-4
Configuring The Wave Generator 15-4
Setting Up The Relay 15-5
Specifying The Auto Toggle Settings 15-5
Running the Instrument 15-6
15.3. Thermocouple Linearization 15-7
Table Columns 15-7
CJC Settings 15-8
15.4. Tutorial: Thermocouple Linearization 15-8
Building the Instrument 15-8
Configuring The Wave Generator 15-9
Linearizing Thermocouple Channels 15-10
Specifying The CJC Settings 15-11
Running the Instrument 15-11
15.5. Smoothing 15-12
Table Columns 15-12
Smoothing Options 15-13
15.6. Tutorial: Smoothing 15-13
Building the Instrument 15-13
Configuring The Wave Generator 15-14
Configuring The Smoothing Element 15-15
Specifying The Rise Time 15-16
Running the Instrument 15-16
15.7. Histogram 15-17
Histogram 15-18
Band Analysis 15-18
Octave Band Analysis 15-18
15.8. Tutorial: Histogram 15-19
Building the Instrument 15-19
Performing A Histogram Calculation 15-19
Running the Instrument 15-21
15.9. MultiFrame 15-22
15.10. Tutorial: MultiFrame 15-22
Building the Instrument 15-22
Summing Five Frames Into One Frame 15-23
Running the Instrument 15-25
Outputting All Five Frames 15-25

FactorySuite

Chapter 16. IndustrialSQL

16.1. Connecting to the Server 16-1
16.2. IndustrialSQL In Settings 16-2
Time Controls and Resolution 16-3
Tree View 16-3
Active Tags 16-3
16.3. Tutorial: Using The IndustrialSQL In Element 16-4
Building the Instrument 16-4
Connecting to the IndustrialSQL Server Database 16-4
Activating Tags 16-5
Selecting the Start and End Dates 16-5
Setting the Resolution 16-6
Running the Instrument 16-6

Appendices

Appendix A. Glossary **A-1**

Appendix B. Bibliography **B-1**

Appendix C. Aliasing **C-1**

Appendix D. DDE Commands and Parameters **D-1**

Appendix E. PC Computer Information **E-1**

Appendix X. Index **X-1**

Chapter 1. Getting Started

1.1. Welcome! **1-1**
1.2. Technical Support **1-3**
1.3. System Requirements **1-5**
1.4. Installing Snap-Master **1-6**
1.5. Computer Configuration **1-6**
1.6. Start Using Snap-Master **1-8**

1.1. Welcome!

Congratulations on purchasing Snap-Master for Windows - the new generation of PC-based data acquisition, analysis, control, and display software from HEM Data Corporation. Snap-Master combines advanced data acquisition and storage capabilities with time and frequency domain analysis and near real-time plotting, all without programming! From high speed data acquisition, display and storage to monitoring and control, Snap-Master has the power to meet the needs of a wide variety of applications.

Snap-Master is divided into three modules: Data Acquisition (SM-DA), Waveform Analyzer (SM-WA, formerly known as General Analysis), and Frequency Analyzer (SM-FA). Each is a fully functional stand-alone package that includes data display, storage, retrieval, and Dynamic Data Exchange (DDE) capabilities. By integrating the different Snap-Master modules you can create a complete software solution to meet your total needs.

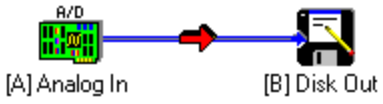
NOTE: *Some chapters and tutorials may contain additional features not included in your Snap-Master software. For more information on how to obtain these additional features, please contact the vendor from whom you purchased Snap-Master.*

Sample Instruments

Included with Snap-Master are sample instruments that demonstrate different features of the program. To open these files, run Snap-Master then select the File menu, Open Instrument command. The Open dialog box will appear with a list of the Instrument files that you can use. Try using the Viewer button in the Open dialog to see the contents of each instrument.

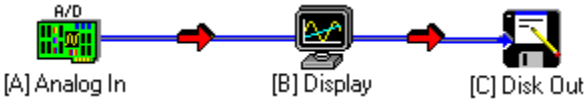
In addition to the instruments included on disk, the following instruments represent the Snap-Master equivalents for many pieces of conventional equipment. It is highly recommended that you complete the Basic Tutorials before you attempt to employ these examples. Once you have become comfortable with Snap-Master, this section can be used as a reference guide to conventional test systems and their equivalent in Snap-Master.

Data Acquisition System



This instrument is representative of a system that will acquire real world data and store it to a disk. An analog input signal is sampled by an A/D (with all sampling parameters specified and maintained by Snap-Master), and the data is stored to a file on a disk. By using Snap-Master's Fast Binary Data Format, you can stream the data to disk at high sampling rates.

Digital Storage Oscilloscope, Strip Chart Recorder, Y-X Plotter, Meter

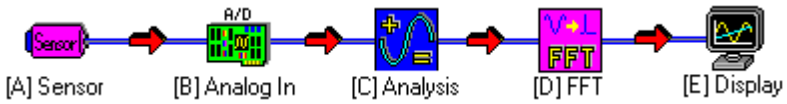


This instrument is similar to the Data Acquisition System but in addition to sending the data to a disk, it is also displayed on the computer monitor. The difference between each of the instrument samples is how the Display element graphs the data. The Digital Storage Oscilloscope emulates an oscilloscope by plotting from right to left against a stationary set of axes and using time as the X-axis. The Strip Chart Recorder is similar, but both the axes and the data scroll continuously from right to left. The Y-X Plotter uses the same configuration as the Oscilloscope but the X-axis is now referenced against one of the input channels, not as a function of time. To emulate a portable volt meter, the Display element plots the numeric data values using the Digital Meter display type.

Waveform Generator, Controller, Monitoring and Diagnostics

The important feature about this instrument is its ability to output both analog and digital signals according to the system's input signal. The input data is analyzed and monitored, resulting in automatic decision making that will initialize subsequent actions for the test system.

Waveform Analyzer, Spectrum Analyzer, Signal Analyzer, Digital Filter



This Instrument configuration allows for analysis and manipulation of data in the digital domain. The Analysis element uses digital filtering to remove unwanted noise from the signal, and the FFT element performs a Fourier analysis on both the original and the filtered signals.

PID Control

This instrument configuration allows for PID (proportional, integral, differential) Control. The A/D is used to acquire the incoming data, the Analysis element calculates the Error and the PID output equations, then outputs a value using the D/A element.

1.2. Technical Support

Registration

Please take the time to fill out and return the Registration Card as directed. Along with information on your software use and needs, the data you provide helps us to serve you more efficiently if you require technical support.

Please be sure to read the Software License Agreement for any warranty and disclaimer information regarding the use of this product.

Customer Support

Unless otherwise warranted by your vendor, registering your software entitles you to basic customer support coverage of :

- Free telephone support for *four (4) months* from date of purchase (duration of support period may vary according to whom you purchased this product from)
- Free product upgrades for *thirty (30) days* from date of purchase

An Extended Support Program (ESP) for continued technical support and software upgrades can be purchased after the standard support policy expires. Please contact an HEM Data sales representative for more information.

If you purchased the software from a third-party reseller, your Customer Support terms (including extended support) may differ. Please contact the company you purchased the software from for further information.

HEM Data reserves the right to withhold customer support service at any time from unregistered users or from anyone who abuses the service. We also reserve the right to change the support fee structure, support policies, and procedures without notice.

Where To Go For Help

To save time, please refer to the applicable software and hardware documentation before calling technical support. Our manuals are designed to provide answers to the questions most commonly asked about the program.

If you have access to the World Wide Web, check out *http://www.hemdata.com* which contains a section with Application Notes with advanced uses of Snap-Master as well special hints and tricks.

If you purchased the software directly from HEM Data, you may call our Technical Support Staff at (248) 559-5607. Technical Support hours are between 8:00 AM and 5:00 PM (Eastern Time Zone). Or, you can fax us your questions 24 hours a day at (248) 559-8008. *Faxing technical support questions is preferred since it is an efficient way to define and illustrate situations or problems. This also allows the support staff time to research the problem before contacting you with solutions.*

If you purchased the software through a third party, contact them directly for technical support.

When You Call For Support

Please register your software before calling for technical support. You may be asked to fax in your registration card if you have not already registered.

The amount of information needed depends upon the complexity of your question. Minimal information generally required for efficient technical support includes:

- Version and build numbers from the Help menu, About Snap-Master dialog box or the Snap-Master installation disks
- System information from the Help menu, About Snap-Master dialog box
- Serial numbers from the Snap-Master installation disks

If at all possible, you should have immediate access to your computer and Snap-Master while you are calling. This helps the technical support representative quickly determine if a proposed solution is valid, as well as gather additional information as needed.

You may be asked to send additional information to help us assist you such as copies of the Snap-Master instrument files, data files, or photocopies of the original Snap-Master diskettes.

What Is Technical Support?

As indicated previously, technical support for Snap-Master is a service provided by the party from whom you purchased the software. In combination with the user's manuals for the software and hardware, technical support is intended to assist you to attain useful operation of Snap-Master.

While not a complete list, the following paragraphs should give you an idea of the services to expect from HEM Data's Technical Support staff:

- **Answers to General Usability Questions** - HEM Data's Technical Support staff will answer general usability questions, which are defined as non-programming issues including: product features, menu commands, formatting, and aspects of the user interface (use of the windows, dialog boxes, etc.). We will also answer general installation questions for both the software and any I/O hardware sold directly by HEM Data.
- **Resolution of Repeatable Problems** - While Snap-Master has endured thousands of hours of testing and millions of hours of use, there are times when you may encounter a repeatable problem with the software. When you call technical support with a description of the problem, please have a complete description of the problem and related circumstances (which means that more information than "Snap-Master crashes when I run it" is required). You may be asked for copies of the instrument, data, or configuration files for Snap-Master, and for the sequence of events leading up to the problem (including anything that has changed since the instrument last ran successfully). Whenever practical, HEM Data will assist in the timely resolution of such problems. However, the only way we can fix such a problem is if we can duplicate it. Your assistance in this area is greatly appreciated.
- **Application and Instrument Design Is NOT Included** - HEM Data's technical support service *does not include* the detailed applying of Snap-Master to the design of a customer's specific application, support customer written code *in any language* to access the features or files created by Snap-Master, or provide support for hardware not sold directly by HEM Data. For assistance in these areas, contact HEM Data for information on our consulting/engineering services.

Because your contact point for technical support is the company you purchased the software from, these technical support services may differ from HEM Data's. Please contact your software vendor for more information on the technical support services they provide.

Extended Support Programs

HEM Data offers a valuable extended support program (ESP) which increases the period of technical support and product maintenance for yearly periods beyond the initial four months. Like our software, our extended support program is designed to focus on our customers' changing requirements. For the duration selected, the Extended Support Program includes:

- General support by telephone and fax
- Assistance in problem diagnosis and resolution
- Free minor software upgrades ("builds"), *when available*, to correct a customer's problem or provides needed functional enhancement. Upgrades distributed via either our World Wide Web page (*http://www.hemdata.com*) or by snail mail
- Automatic free upgrades to major software upgrades (i.e. from 3.2 to 3.3 or 4.0) released during the support period
- A subscription to our technical newsletter
- Discounts on training, seminars, and engineering consultation

The price of an Extended Support Programs depends on the software module(s) and period covered. You **must** be a registered user and own the current version of the software to enroll in a support program. You may have to pay an upgrade fee to bring your product up to the current version level. Please contact HEM Data for current pricing or if you need more information.

1.3. System Requirements

In order to use this product, you will need the following hardware and software:

- Windows 3.1 or higher
- A computer which runs Windows in 386 Enhanced mode (386 or greater)
- 5-7 MB free hard disk space (plus space for data files)
- 4 MB RAM (8 MB recommended)
- Mouse or other pointing device
- For high speed plotting a local bus graphics accelerator is recommended
- For high speed data analysis, a math coprocessor is recommended

1.4. Installing Snap-Master

Snap-Master's installation program is used for both new installations and upgrades to existing installations. To install or upgrade Snap-Master, follow these instructions:

- Insert Disk 1 of the most recent Snap-Master module you received (for example, Disk 1 of the Data Acquisition module)
- In Program Manager, select the File menu, Run command (for Windows 95 users, select the Start button, Run command)
- Type *a:setup* in the command line (use the floppy disk drive letter you are installing from), then press the OK button
- When you reach the screen that specifies the destination path for Snap-Master, type the hard disk directory where you want to install the program (the default is C:\SM). If you are performing an upgrade, type the directory where Snap-Master is already installed
- When you reach the screen that lists the installation or upgrade options, select the check boxes of the Snap-Master modules you are going to install or upgrade.
- Follow the instructions on screen and insert the correct diskettes as the installation program asks for them. The installation program will add an icon for the latest installation of Snap-Master. When installation is completed, double click on the new icon to start the program.

1.5. Computer Configuration

Snap-Master operates under Microsoft Windows 3.1. If you are using Windows 3.0, you must upgrade to Windows 3.1 before you can run Snap-Master.

The About Snap-Master dialog box contains information about Snap-Master and the support libraries, as well as information about your computer. This information can be recalled at any time from the Snap-Master workspace with the Help menu, About Snap-Master command.

Windows 3.1

After Snap-Master is installed, you may need to check the CONFIG.SYS and AUTOEXEC.BAT files (located in the root directory of your startup drive). If any of these files are found, please read the following information for further details.

HIMEM.SYS — This is the extended manager program distributed with MS-DOS and Windows. All Windows programs use extended memory to access the memory above 640 KB. Therefore, Snap-Master is designed to work with HIMEM.SYS. Make sure that the following line is contained in the CONFIG.SYS file (substitute the directory where your copy of HIMEM.SYS is stored): *DEVICE*=**C:\WINDOWS***HIMEM.SYS*.

EMM386.EXE
QEMM.SYS
386MAX.SYS — This program emulates expanded memory using the installed extended memory. Some non-Windows applications use expanded memory, but all Windows programs use extended memory. If you encounter problems with data acquisition, try removing all expanded memory emulation programs from the CONFIG.SYS file. For more information about extended and expanded memory, refer to your DOS or Windows manuals.

SHARE.EXE — If you have installed the Data Acquisition Module, you may need to install SHARE (which comes with DOS) in order for the Sensor database to operate correctly. If you receive the error message "Is SHARE loaded?" when adding a Sensor element to the instrument, add the following command to your CONFIG.SYS (substitute the directory where your copy of SHARE.EXE is stored): *INSTALL=***C:\DOS***SHARE.EXE*

The following CONFIG.SYS and AUTOEXEC.BAT files are the "bare minimum" requirements for Snap-Master to operate correctly. If you are using other software programs, your routines may differ slightly. When calling for technical support, you may be asked to either fax a copy of your CONFIG.SYS and AUTOEXEC.BAT files, or you may be asked to try the following files. For more information on these commands, refer to your DOS and Windows manuals.

CONFIG.SYS

```
DOS=HIGH,UMB
DEVICE=C:\HIMEM.SYS
FILES=30
BUFFERS=30
STACKS=9,256
```

AUTOEXEC.BAT

```
@ECHO OFF
PROMPT $p$g
PATH=C:\DOS;C:\WINDOWS
```

386 Enhanced Mode

Windows 3.1 has two operating modes: Standard Mode and 386 Enhanced Mode. For Windows 3.11 and higher (including Windows for Workgroups), only 386 Enhanced Mode is available. If you attempt to start Windows in Standard Mode, you will receive an error message.

The major differences between the two modes are how DOS sessions are handled and virtual memory. In 386 Enhanced Mode you can have multiple DOS sessions running concurrently, while Standard Mode only allows one DOS session at a time. Also, 386 Enhanced Mode allows you to use part of the hard drive to emulate RAM using virtual memory.

Because 386 Enhanced Mode allows for multiple “Virtual DOS Machines,” certain tasks operate more slowly than in Standard Mode. In Snap-Master, this will usually be most evident while performing high speed data acquisition. If you encounter frequent overruns while acquiring data, try switching to Standard Mode using the */s* command line switch when starting Windows.

When you are using the Data Acquisition Module to acquire data, you must allocate memory for any I/O hardware which uses DMA (Direct Memory Access) to transfer data from the hardware to the computer. For hardware that does not use DMA, you do not need to allocate any special buffers.

In general, any I/O hardware that uses DMA requires a 64 KB (kilobyte) block of memory to write into. Therefore for each I/O hardware function that uses DMA, you need 64 KB of memory in the buffer. If you encounter messages in the Status Log telling you that no buffer could be allocated, you must either increase the size of the buffer or close other instruments in the workspace that contain DMA hardware elements.

When Windows is running in 386 Enhanced Mode, Snap-Master uses a VxD (Virtual Device Driver, which is installed automatically with Snap-Master) to allocate a block of memory for DMA. To set the amount of memory allocated for DMA data transfer, select the Options menu, then the Global Settings command. Change the setting for # of DMA Boards to the maximum number of DMA-based I/O hardware devices you will be using simultaneously. You must restart Windows to have your changes take effect.

Standard Mode

If you are running Windows 3.10 in Standard Mode, you must run the SMSTART program to allocate memory for DMA-based data acquisition hardware before running Windows. The instructions for using the SMSTART program are as follows:

- If you are currently running Windows, exit Windows. DO NOT use the DOS shell within Windows to run the SMSTART program.
- Change to the SM directory where the Snap-Master program resides.
- Type *smstart /x"win /s"*. Press ENTER.

  This command runs the Snap-Master support program and runs Windows in Standard mode. If Windows does not start, try typing the complete path name of your Windows files before the win command (for example *smstart /x "c:\windows\win /s"*).

  If you include this command in your AUTOEXEC.BAT file, the SMSTART program is executed and Windows runs in Standard mode each time you start your machine. This command MUST be in the last line your AUTOEXEC.BAT file.

Another option is to create a batch file that will run SMSTART, Windows in Standard Mode, and Snap-Master. The batch file might look like this:

```
cd\sm
smstart /x"c:\windows\win /s sm.exe"
cd\
```

To allocate more memory for SMSTART, you can include a number (expressed in Kilobytes) after the SMSTART command (for example, SMSTART 256 allocates 256 KB of memory). By default, SMSTART allocates 128 KB of memory. For additional information about the SMSTART program, type *smstart /?*.

Windows 95

All of Snap-Master's features and capabilities are available when running under Windows 95. All comments about allocating buffers for data acquisition in the 386 Enhanced Mode section apply to Windows 95 as well.

Windows NT

Snap-Master operates as a data display and analysis program when running under Windows NT. The data acquisition features are not available.

Using Disk Compression or Caching Software

When using any type of disk compression software (such as DoubleSpace or Stacker), the actual throughput rate for writing high speed data to disk in the Fast Binary format will decrease. The actual performance for all data file formats will vary between computers. As a rule of thumb, avoid writing high speed data to compressed disks.

You should disable any disk caching software (such as SMARTDRV) if you are acquiring data using the Fast Binary format. SMARTDRV is automatically installed with Windows 3.1, so you will have to remark this out of AUTOEXEC.BAT before using the FBDF format.

1.6. Start Using Snap-Master

This manual is designed to give you an overview of Snap-Master's components and how they work together. Many basic examples are provided along the way to help get you started. These tools will help you construct your more complicated tests in less time using Snap-Master. Enjoy!

Chapter 2. Snap-Master Basics

2.1. Workspace 2-1
2.2. Elements 2-10
2.3. Instruments 2-15
2.4. Tutorial: Creating Your First Instrument 2-16
2.5. A/D Demo Element 2-20
2.6. Tutorial: Changing A/D Demo Parameters 2-21

2.1. Workspace

When you start Snap-Master, the main workspace appears. The function of the workspace is to hold the instrument windows, and to provide an easy way of building new instruments. The workspace has its own title bar and menu as well as other key features, as shown in Figure 2-1.

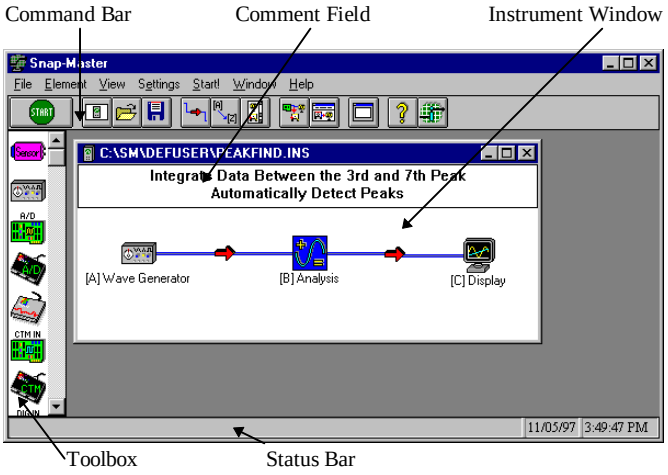


Figure 2-1 Snap-Master Workspace

Command Bar

Most of the windows you will encounter in Snap-Master have a Command Bar located directly below the menu. Each Command Bar provides buttons for the most commonly used menu commands in that window. As you move the mouse pointer over a button, the description of the button's function appears in the Status Bar.

Some of the common buttons you will find throughout Snap-Master are:

Button	Description
	Starts and stops the active instrument
	Creates a new window or clears the current settings
	Opens an existing file
	Saves the current settings

Buttons that are unique to the Workspace are:

Button	Description
	Turns Pipe Mode on or off.
	Turns Re-Letter Mode on or off.
	Opens the Element list dialog box..
	Arranges the icons in the instrument window.
	Opens the Instrument Settings dialog box.
	Opens the Status Log.
	Opens the Snap-Master Help Contents.
	Opens the About Snap-Master dialog box.

Status Bar

Most Snap-Master windows have a Status Bar at the bottom of the screen which shows both the description of a Command Bar button as you move the mouse pointer over it, as well as any Snap-Master messages from the Status Log. These messages include which instrument is running, triggering messages, and errors that may occur. In the lower right corner of the Status Bar, the current date and time is displayed.

Toolbox

The Toolbox, located on the left side of the workspace, contains the various element icons used to create an instrument. When building an instrument, simply click on an icon in the Toolbox, then drag it over the instrument window and drop the icon.

Some icons in the Toolbox represent several elements of the same type, such as when you have more than one A/D driver installed. Clicking once on the icon in the Toolbox displays a pop-up menu which shows the different elements using the icon. The item that has a check mark next to it is the element that will be placed in the instrument when the icon is dragged from the Toolbox and dropped in the instrument window. To change the checked item, select a new option from the pop-up menu.

Instrument Window

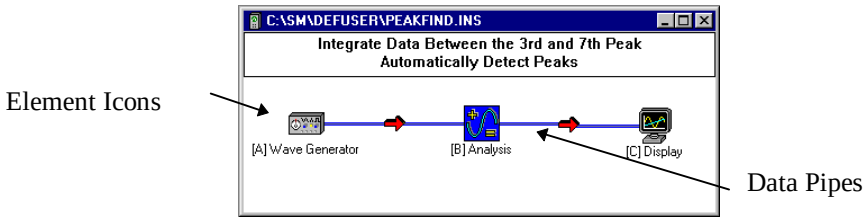


Figure 2-2 Instrument Window

The instrument window is where the actual construction of an instrument occurs. Element icons are dragged from the Toolbox and dropped in the instrument window, then they are connected together with data pipes. With the arrangement of the elements under your control, it is easy to see where the flexibility and power of Snap-Master comes together.

An instrument is a flow chart diagram, where each element represents a specific function and the data pipes show how the data moves between elements. Each piece of the test setup is represented by a unique element icon, such as the monitor of the computer which is represented by the Display element. The flow chart represents an overview of the instrument's functionality. To look at the details behind each element, simply double click on the icon to open up the settings.

When you include a new element in the instrument, notice that each element is assigned a unique element letter which appears in brackets before the element name. These letters are used to distinguish between elements of the same type (for example, if two A/D Boards are used in the same instrument), and to designate data channels to and from each element. Channels are always referenced by their element letter and channel number in Snap-Master (for example, channel A0 is channel number 0 from element letter A).

The workspace can have multiple instruments open, but only one instrument is running at one time. When you press the Start button or select the Start menu command, the active instrument window is the one that is started. You can view the contents of the other instruments loaded in the workspace while another instrument is running, but you cannot start another instrument until the first instrument is stopped.

Comment Field

The Comment Field in the instrument window is a text box where you can enter any additional information about your instrument. Helpful text might include a title for the instrument or a specific use of that particular configuration.

File Menu

New Instrument Create a new instrument window.

Open Instrument... Open a saved instrument.

Instrument Viewer

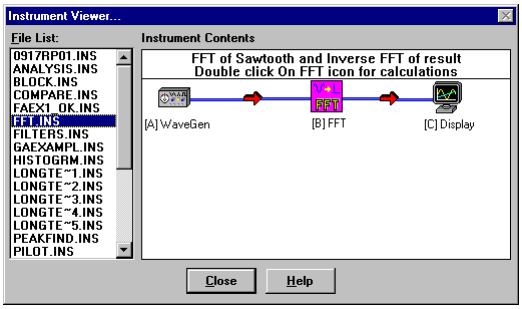


Figure 2-3 Instrument Viewer

In the Open Instrument dialog, there is a Viewer button which opens the Instrument Viewer. The Instrument Viewer lists all of the instruments in the current directory (set in the File Open dialog). When you click on an instrument in the File List, an overview appears in the Contents picture box including the icons and comments in the instrument. Pressing the Close button automatically enters the name of the instrument in the File Open dialog.

Save Instrument Save the instrument.

Save Instrument As... Save the instrument as a new file.

Close Instrument Closes the active instrument.

Exit Program Exits Snap-Master.

Element Menu

Pipe Mode When creating an instrument, the flow of data between elements is defined by the connection of data pipes. These pipes are directional and include an arrow indicating the direction of "flow". To activate or deactivate Pipe Mode select the Elements menu, Pipe Mode command or press the button in the Command Bar.

Connecting Elements

To connect two elements together, use the following procedure:

- When the Pipe Mode cursor is (the arrow points to the upper left) click once on the source element, or the element where the data is coming from.
- When the Pipe Mode cursor is (the arrow points to the lower right), click once on the destination element, or the element where the data is going to. The elements are now connected so that data flows between them in the direction shown.
- Repeat for as many connections as your instrument needs.

Disconnecting Elements

To disconnect the pipe between two elements, use the same procedure used for connecting the elements.

- When the Pipe Mode cursor is (the arrow points to the upper left) click once on the source element.

- When the Pipe Mode cursor is (the arrow points to the lower right), click once on the destination element. The pipe between the elements is cleared.

Re-Letter Mode

Each element in a Snap-Master instrument has an associated element letter which is used to distinguish the different elements. Using Re-Letter Mode, you can change the element letter for any element icon in the instrument.

To activate or deactivate Re-Letter Mode select the Elements menu, Re-Letter Mode command or press the button in the Command Bar. When Re-Letter mode is active, the mouse pointer changes to

To change the element letter of an element, use the following procedure:

- Click on the element you wish to change. This opens the Re-Letter dialog box. The current element letter is selected in the dialog, and all element letters that are already in use are inactive.

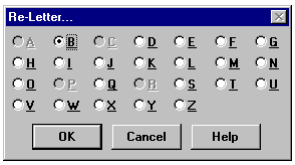


Figure 2-4 Re-Letter Dialog Box

- Select an available element letter, then select the OK button.

NOTE: If you change an element letter, then you may need to tell the other Snap-Master elements. Most elements retain the reference to the original channel in the case that the channel is re-used in the instrument. If you do not want to use the old element letter, you will need to make the reassignments.

More Elements

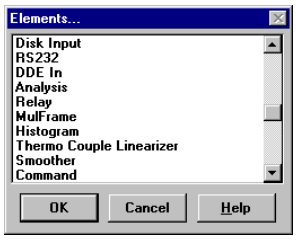


Figure 2-5 Element List

The Elements dialog lists all of the available elements installed in Snap-Master. When you select an element from the list by either double-clicking on it or by selecting an item and pressing the OK button, the element is placed in the instrument. Pressing the Cancel button averts putting a new element in the instrument.

View Menu

Command Bar

Turn the Command Bar on or off.

Status Bar

Turn the Status Bar on or off.

Toolbox

Turn the Toolbox on or off.

Status Log

Figure 2-6 Status Log

The Status Log is where Snap-Master queues time-stamped operating messages and errors. Under normal operating conditions, you will not need to view the Status Log. However if an error occurs in an instrument, a message is logged and the Status Log appears automatically. Errors are indicated by the keyword ERROR preceding the time stamp, followed by the error message. Errors might include A/D Overruns, out of memory, sensor out of calibration, etc.

The contents of the Status Log can be saved to a text file using the Save As button. This text file may be used by the technical support staff to diagnose problems. Pressing the Save As button opens the standard Windows File Save dialog, where you can specify the file name.

Settings Menu

Auto Arrange

When the Auto Arrange function is selected (indicated by a check mark), each element you add to the instrument is automatically placed according to the Icon Spacing setting. If the icon disappears, resize the instrument window vertically to find it.

The distance between elements is controlled by the Icon Spacing parameter in the Desktop section of the Control Panel in Windows. The recommended setting for the Icon Spacing is 100.

Global Settings

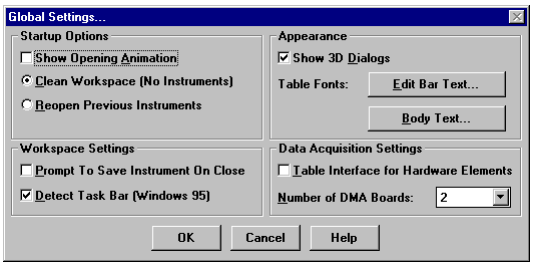


Figure 2-7 Global Settings

The Global Settings dialog box controls parameters used throughout Snap-Master.

Startup Options

Show Opening Animation — When selected, the Snap-Master logo is animated when you start Snap-Master. To speed up loading time, turn this option off.

Clean Workspace — Opens Snap-Master without any instruments in the workspace.

Reopen Previous Instruments — Opens the instrument files you were working on when you last exited the Snap-Master workspace.

Workspace Settings

Prompt To Save Instrument On Close — When you close an instrument from the workspace, Snap-Master normally checks to see if the file has changed since it was last saved. If the instrument has changed, you are asked if you want to save your changes. To skip the comparison and close the file immediately, turn off the check box. This is the recommended setting for any programs using the Front Panel Library.

Detect Task Bar (Windows 95) — When selected, Snap-Master checks for the Windows 95 task bar on the screen when opening windows from the workspace. Windows 3.1 users should leave this check box unchecked.

Appearance

Show 3D Dialogs — Shows all Snap-Master dialogs with gray backgrounds (you must restart Snap-Master for the changes to take effect).

Edit Bar Text — Sets the font for the upper edit bar in all tables (you must close any open tables for the changes to take effect).

Body Text — Sets the font for the cells in all tables (you must close any open tables for the changes to take effect).

Data Acquisition Settings

Table Interface for Hardware Elements — When selected, all HDI-compatible hardware elements use a table interface to set up the channels. When turned off, the element uses the original dialog based user interface.

Number of DMA Boards — O*nly used while acquiring data using Hardware (DMA) mode.*

Determines how much upper memory is allocated for high speed data transfer between the DMA (Direct Memory Access) acquisition hardware and the computer. If you do not use the Data Acquisition Module OR your acquisition hardware does not require DMA, set the number to "0." If you change the number of boards, you MUST restart Windows (not just Snap-Master) for the change to take effect.

Instrument Settings

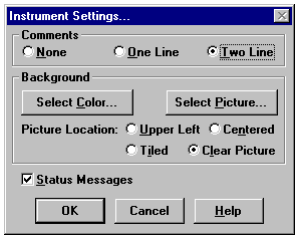


Figure 2-8 Instrument Settings

The Instrument Settings dialog customizes the appearance of the instrument window.

Comment Field

The Comment Field group determines the number of lines displayed in the Comment Field. Any text stored in the Comment Field is retained regardless of the number of lines showing.

Background

The Background settings allow you to specify a new background color or picture for the instrument window. Finally, the Status Messages check box determines if the Start and Stop instrument messages are sent to the Status Log. Turning Status Messages off decreases the number of messages posted in the Status Log.

Status Bar Settings

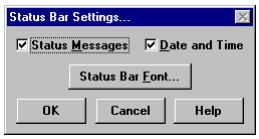


Figure 2-9 Status Bar Settings

Visible
Check boxes specify if the current Date and Time or any Status Messages from the Status Log appear in the bar. When you are debugging an instrument's operation, you may want to turn on the Status Messages check box to display all messages (such as Waiting for Trigger, etc.).

The Font Selection button select the font and point size for that window's Status Bar.

Start! Menu

Begins operation of the active instrument. When the instrument is running, the menu changes to include only the **Stop!** command.

Window Menu

Cascade Show all instrument title bars.

Tile Show all instruments.

Arrange Icons Immediately arranges the icons in both the instrument window and the workspace according to the Icon Spacing setting.

Help Menu

Contents Open the Snap-Master Help contents.

How To Use Help How to use the Windows Help program.

Snap-Master Tutorial Open the Snap-Master Help tutorials.

About Snap-Master

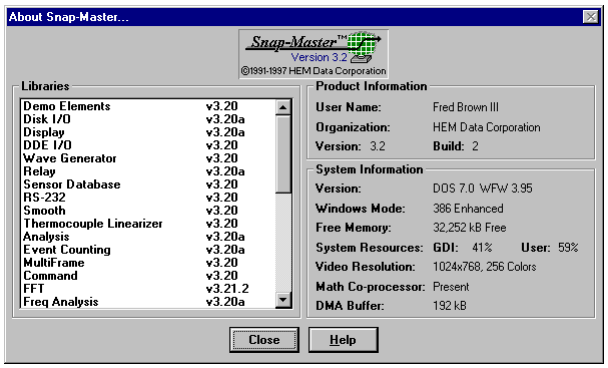


Figure 2-10 About Snap-Master Dialog Box

The About Snap-Master dialog box provides important information about the libraries loaded by Snap-Master and the configuration of your computer. This information is important to know when calling for technical support, so please be prepared to provide this information.

HINT: To make a screen copy of this dialog box or any window, hold down the ALT key and press PRINT SCREEN. You can then paste the image as a picture in other applications such as a word processor or graphics program.

If you want to copy the complete list of libraries and version numbers to the Clipboard as text, double click in the version list box.

2.2. Elements

Overview of Elements

The building blocks of a Snap-Master instrument are the elements, which represent a specific piece of hardware or a software process. When you combine elements into an instrument, you have a customized setup that gives you maximum control over each facet of a test setup.

Each element can be classified as either an Input Element, an Analysis Element, or an Output Element. An Input Element brings newly acquired or previously stored data into the instrument. An Analysis Element processes the data to extract specific information as defined by the user. Output Elements allow you to store and view the data, or send data to external equipment.

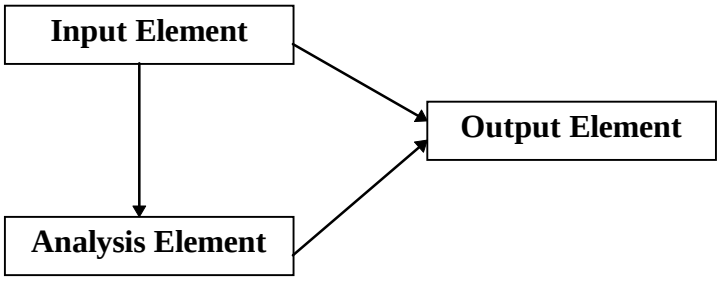


Figure 2-11 General Data Flow In Instrument

Input Elements

Input elements bring data into the instrument.

	Sensor	Integrated database of sensors and transducers which scales voltages to engineering units. The Sensor Database also a calibration history.
	Signal Conditioner	Controls supported software programmable signal conditioning hardware.
	Wave Generator	Generates fixed function and arbitrary waveforms.
	Analog-to-Digital Input	Receives analog data from A/D hardware. When placed in an instrument, the element name changes to the model of the hardware. Some hardware may use another icon.
	Digital Input	Receives digital data from Digital Input hardware. When placed in an instrument, the element name changes to the model of the hardware. Some hardware may use another icon.
	Counter Timer Input	Receives digital data from Counter Timer hardware. When placed in an instrument , the element name changes to the model of the hardware. Some hardware may use another icon.
	External Box In	Receives data from generic external hardware devices, such as RS-232 hardware.
	Disk In	Reads data stored in a file on a floppy, hard, or RAM disk. Reads files written in binary and ASCII formats, as well as Snap-Series for DOS files.
	DDE In	Receives data in real-time from other programs via Dynamic Data Exchange, or DDE. If you are on a Microsoft Network computer (such as Windows for Workgroups), you can also receive data from other computers running Snap-Master.

Analysis Elements

Analysis elements process data from Input elements and output the results to other Analysis elements or Output elements.

	Relay	Acts as a data controlled switch to turn data pipes on and off while the instrument is running.
	Thermocouple Linearizer	Converts the voltage input from a thermocouple into temperature units.
	Smoothing	Performs a low-pass smoothing filter on the selected channels.
	Analysis	Performs time domain calculations and outputs the results as new data channels.
	MultiFrame	Performs summing or averaging in either the time or frequency domain over multiple frames of data.
	Histogram	Performs summation, averaging, or counting on data to produce data grouped into bins.
	Command	Performs commands based on logical decisions using IF..THEN..ELSE statements.

	FFT	Converts time domain data to the frequency domain using Fast Fourier Transform, power spectra, transfer and coherence functions and outputs the results as new data channels.
	Frequency Analysis	Performs calculations on the magnitude portion of frequency domain data using the same tools as the Analysis function.

Output Elements

Output elements send data from Input and Analysis elements to another medium, such as a plot, data file, or external signal.

	Display	Displays data on the computer monitor in a variety of formats.
	Digital-to-Analog Output	Outputs analog data using D/A hardware. When placed in an instrument, the element name changes to the model of the hardware. Some hardware may use another icon.
	Digital Output	Outputs digital data using Digital Output hardware. When placed in an instrument, the element name changes to the model of the hardware. Some hardware may use another icon.
	Disk Output	Writes data files to a floppy, hard, or RAM disk in binary and ASCII formats.
	DDE Out	Outputs data from the Snap-Master instrument to another DDE-aware application.

Menus And Command Bar

Each of the window and table based elements share a common set of menu commands and associated Command Bar buttons.

The common Command Bar buttons, their function, and the equivalent menu commands are as follows:

Button	Description
	Clears all element settings
	Opens an existing element settings file
	Saves the current element settings to a file
	Undo the last command.
	Cut the selected cells and send to the Clipboard.
	Copy the selected cells and send to the Clipboard
	Pastes the Clipboard contents to the selected cell in the table.

Insert a new row in the table at the current row

Appends a new row after the current row

Deletes the current row

Prints the current table contents

File Menu

New Settings Clears all settings for the element and restores the default settings.

Open Settings Imports a saved element settings file into the current instrument.

Save Settings Exports the current element settings to a previously specified file name.

Save Settings As Exports the current element settings to a new file.

Print Table Prints the contents of the table to the default printer.

Print Setup

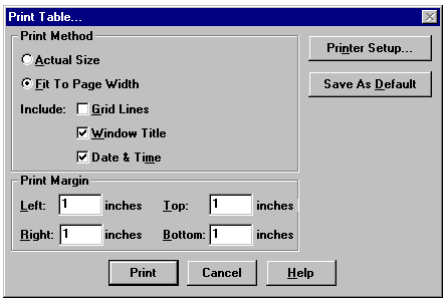


Figure 2-12 Print Table Setup

Opens a dialog to configure the printing of this table.

Print Method

Actual Size	Uses the table font sizes to print the table at full size.
Fit To Page Width	Reduces the table so the entire width of the table prints on one page.
Grid Lines	When selected, the grid lines from the table are printed.
Window Title	When selected, the title of the window is printed at the top of the page.
Date & Time	When selected, the current date and time are printed in the bottom left corner of the page.

Print Margins

Specifies the margins for the printout on each side of the page.

Save As Default Saves the current settings in this dialog as the default method. When the Print command is issued, the default settings are used.

Close Closes the element window. This does not remove the element from the instrument.

Edit Menu

Undo Reverses the last action performed.

Redo Reverses the last Undo performed.

Copy For table based elements, copies the current row as text.

Copy All Copies the entire contents of the table as text.

Insert Adds a new row in the table at the current row, shifting all rows below the current row down.

Delete Deletes the currently selected rows from the table.

Append Appends a new row in the table.

Insert Stage Add a new stage before the current stage.

Find Finds the next instance of the specified text.

Replace Replaces the next instance of a text string with the specified text.

View Menu

Command Bar Turn the Command Bar on or off.

Status Bar Turn the Status Bar on or off.

Table Columns

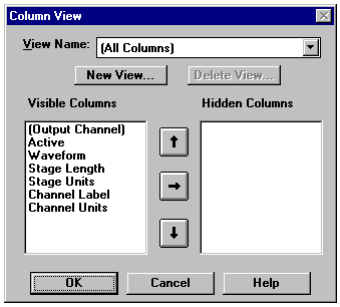


Figure 2-13 Table Columns View

The Table Columns View settings configures which columns are visible in each table by View name. Each table has its own separate views and visible columns.

Creating A New View

- Select the New View button.
- Enter the name of the new view.

Changing An Existing View

- Move the columns you do not want to see by selecting the items in the Visible Columns list and pressing the → button to move them to the Hidden Columns.

- Change the order of the Visible Columns by selecting the items in the list and using the ↑ and ↓ buttons.

Deleting A View

- Select the view from the View Name combo.

- Press the Delete View button to remove the view.

2.3. Instruments

Instrument Construction Guidelines

Now that you have been introduced to the basic concepts used in Snap-Master, it is time to present the guidelines and strategies for proper setup and use of your instruments. These instructions will optimize the results of your instrument and your use of Snap-Master.

When connecting elements together into an instrument, it is important to follow the conventions given by Figure 2-11. This figure can be summarized as follows:

- Input Elements send data to Analysis and Output Elements

- Analysis Elements send data to Output Elements

An important item to remember is that data pipes send information through elements, so that information can be received "downstream" using a minimum number of data pipes. For example, the instrument shown below shows data being sent from the A/D Board to the Analysis element, and through Analysis to the Display element. As a result, the Display element can show data from both the A/D Board and the Analysis elements.

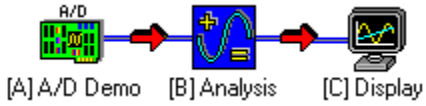


Figure 2-14 Directionally Correct Instrument

The organization of the Toolbox also acts as a guide to the valid connections between elements. In general, elements that are positioned higher in the Toolbox can be connected to an element that is positioned lower in the Toolbox.

Here are some general rules to follow when building an instrument:

- Use the same element topology in Figure 2-11 when positioning the elements.

  The Input → Analysis → Output topology allows data to flow in a left to right direction, using the element and data pipe arrows as indicators of "data in" to "data out". It will also help to identify the different types and general functions of the elements.

- Minimize the number of elements you send data through.

  Using the minimum number of data pipes allows for the fastest transfer of data between elements. In addition, it simplifies the flow-chart view of the instrument.

- Keep all data pipes in view and not hidden behind elements.

  By keeping all data pipes in view, you will reduce the risk of error and will aid in troubleshooting the instrument. When you move an element, all of its connected data pipes move with it.

Frame Characteristics

Every channel in Snap-Master has specific frame characteristics, which consist of:

- Sample Rate
- Number Of Points Per Frame
- Duration Of Frame (calculated by dividing the number of points per frame by the sample rate)

These characteristics are determined on a per element basis. In other words, all channels that share an element letter have the same frame characteristics. Also, all elements that create any data (such as A/D, Wave Generator, Analysis, etc.) must have frame characteristics associated with the element.

At the end of each frame, every element reinitializes itself. As a result, there is an indeterminate amount of time between data frames. Frames are designed for unattended captures of the same type of data, such as using a trigger to capture 5 seconds after a particular event occurs. If you are trying to acquire continuous data, you can set up a long frame (up to 2,147,483,647 points) so there are no gaps in the data.

The usage of these frame characteristics becomes important when using the Analysis element to perform calculations using multiple element letters. Please refer to the Analysis chapter for more information on how frame characteristics are determined for different equation sets.

2.4. Tutorial: Creating Your First Instrument

This tutorial illustrates the basic tasks for creating an instrument in Snap-Master. We will create a simple instrument consisting of the A/D Demo and a Display (these elements are used in most of the tutorials).

The descriptions given in this section are extremely detailed, which is provided for newcomers to the Windows environment. Later tutorials contain less detail in regard to the general user interface.

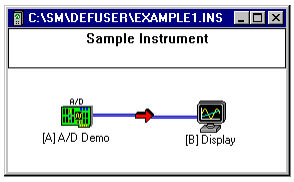


Figure 2-15 Your First Instrument

Creating a New Instrument

1. If any instruments are open in the workspace, close them using the File menu, Close Instrument command.

2. If the Toolbox containing the element icons is not visible, select the View menu, Toolbox command.

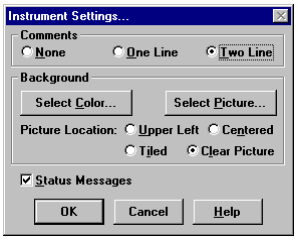
   This places the Toolbox containing the available element icons on the left side of the Snap-Master workspace. When the Toolbox is open, a check mark appears next to the Toolbox menu item.

3. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

   This opens a clean, untitled instrument window in the workspace.

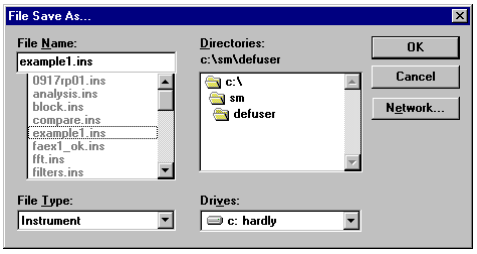
4. Type *Sample Instrument* in the Comment Field.

   The Comment Field is a place where you can type information about the instrument. To type comments, use the mouse to position the arrow cursor over this field, then click the left mouse button. A flashing vertical bar will appear in the comment field. When this vertical bar is present, you can type the information in to the comment field.



   If the Comment Field is not visible, double click in the instrument window or select the button in the Command Bar to open the Instrument Settings dialog. Select the Two Line Option in the Title group, then press the OK button.

5. Save the instrument as *EXAMPLE1* with the button or select the File menu, Save Instrument As command.



   Because this is the first time the instrument is being saved, the File Save As dialog box appears. The File Name field is highlighted, so all we have to do is type *EXAMPLE1*.

It is not necessary to type the .INS extension in the file name because Snap-Master will automatically add it for you. It is not recommended that you specify an extension other than .INS. The default directory for your instruments is the DEFUSER subdirectory, which is what we will use for this example.

NOTE: It is important to save your files frequently so that no information is lost. The tutorials are designed to remind you to save the data at the end of each section.

Placing and Connecting the Elements

1. Place the A/D Demo element

in the instrument window.

   Position the mouse pointer over the A/D Board icon in the Toolbox. Click on the left mouse button. If you own the Data Acquisition module, a pop-up menu might appear with a list of installed A/D Board drivers. If it does, select the A/D Demo option from the list. A check mark indicates which driver is currently selected.

   Position the mouse pointer on the A/D board, then click and hold the left mouse button. When you move the mouse, the cursor will change to the outline of the A/D Board. Drag the A/D Board cursor from the Toolbox until it is over the instrument window (underneath the comment field), then release the mouse button. The A/D Demo element icon should appear in the instrument window.

   Notice that when you place the A/D Demo element in the instrument, it is assigned the element letter “A”. This letter is used by Snap-Master to distinguish the channels from each element because no two elements can have the same element letter. For example, channel 0 will be referred to as channel A0 by the other elements in the instrument.

   Check to make sure that the text underneath the icon says "[A] A/D Demo". If it does not, press the DEL key to delete the element from the instrument. Return to the beginning of this step, remembering to select the A/D Demo element from the pop-up menu on the A/D element icon in the Toolbox.

2. Place the Display element in the instrument window.

   Position the Display element to the right of the A/D Demo element. Follow the same instructions given for the A/D Demo element. Because there is only one Display element, no pop-up menu will appear.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the A/D Demo element to the Display element.

   For this data pipe, the A/D Demo is the source element, and the Display is the destination element. Therefore, we will connect from the A/D Demo to the Display.

Position the mouse pointer over the A/D Demo element icon, then click the left mouse button. The mouse pointer changes to , with the arrow pointing down and to the left. As you move the cursor towards the Display element, a data pipe connected to the A/D Demo element follows the cursor movement. Position the mouse pointer over the Display element icon, then click the left mouse button. A data pipe appears between the elements, with the data pipe arrow pointing from the A/D Demo to the Display, indicating the flow of data.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument command.

When you save the file this time, Snap-Master remembers the file name you specified previously and updates the file.

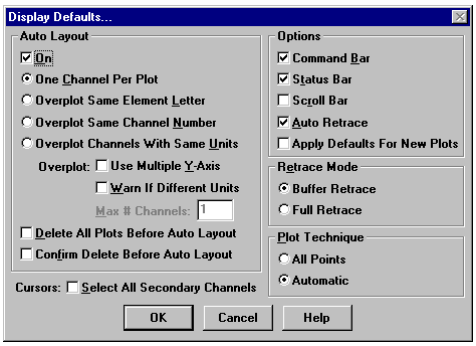
Running the Instrument

Before we run the instrument, let's make sure the Auto Layout function is set up to create a new plot for each channel.

1. Double click on the Display element to open the Display window.

If there are four plots (one for each channel from the A/D Demo) in the window, you can skip step 2.

2. Select the Options menu, Default Settings command to open the Default Settings dialog.



Make sure the On check box is on, the One Channel Per Plot setting is selected, and the Delete All Plots Before Auto Layout check box is turned on. When you are done, press the OK button. If four plots do not appear select the Options menu Auto Layout command.

3. Press the button or the Start! menu command.

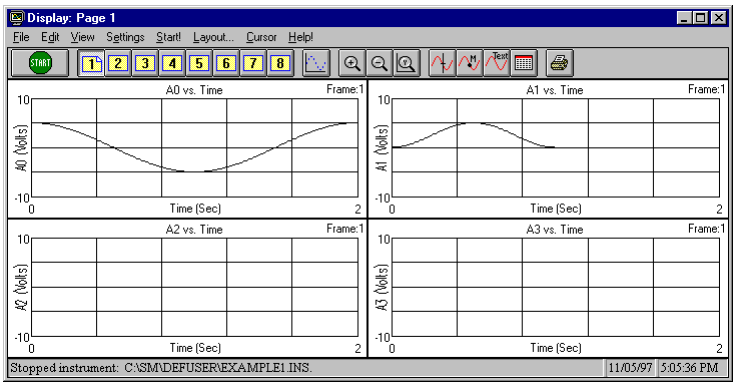


Figure 2-16 Display Window

That's all there is to it! Using a few simple steps, you can display data from any element that outputs data. Of course, it is possible to configure the elements to perform more specific tasks, but even that is not difficult. Throughout the manual, we will illustrate features with specific tutorials.

When you are done looking at the data, press the

button or the Stop menu command.

2.5. A/D Demo Element

The A/D Demo element mimics the operation of A/D I/O hardware in Snap-Master by generating arbitrary waveforms according to the parameters given in the A/D Settings dialog. The A/D Demo element is used for most of the tutorials in this manual, regardless of which modules you have installed.

A/D Demo Settings

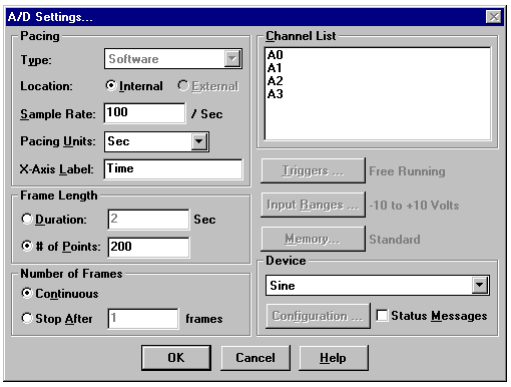


Figure 2-17 A/D Demo Settings

Pacing The Pacing parameters define the "sampling rate" of the A/D Demo element. The units are normally defined in seconds (as indicated by the Units field), with the X-Axis Label defined as Time. The number in the Sample Rate field defines how many times per second the A/D Demo element generates a value for each channel. The maximum sample rate for the A/D Demo element is 1000 samples per second.

Frame Length

You can define the size of each data frame by specifying either the amount of time or number of data points per frame. The frame length is equal to the number of points multiplied by the sample rate. A frame is analogous to the sweep time of traditional oscilloscopes.

At the end of each frame, the element reinitializes itself. As a result, there is a break between data frames. This is not as important with the A/D Demo element as with other elements.

Number of Frames

The Number of Frames group allows you to specify how Snap-Master will run the instrument. When the Continuous option is selected, the instrument will continuously acquire data frames until the user presses the Stop button. To have the instrument acquire a specific number of data frames, select the Stop After option and type the number of frames in the Stop After text field. For example, if Stop After is selected with a value of 5, Snap-Master will acquire five frames of data and automatically stop the instrument

Channel List

The A/D Demo element always outputs four channels of data, numbered 0 through 3. Any selection made in the Channel List field is ignored.

Device

The A/D Demo element can output one of two types of waveform: sine waves or sawtooth waves. Use the Device list to select the wave type.

Status Messages

Selecting the Status Messages check box tells the A/D Demo element to send operating messages to the Status Log. Under normal operation, this option should be turned off. If an error is encountered during operation of the instrument, the message will be sent to the Status Log regardless of the Status Messages setting.

2.6. Tutorial: Changing A/D Demo Parameters

Let’s change the operation of the instrument we built in the previous tutorial by altering the A/D Demo parameters. This example illustrates the concept of frames in Snap-Master and how all of the A/D Demo element's parameters interact with each other to form a frame.

Changing the Sample Rate

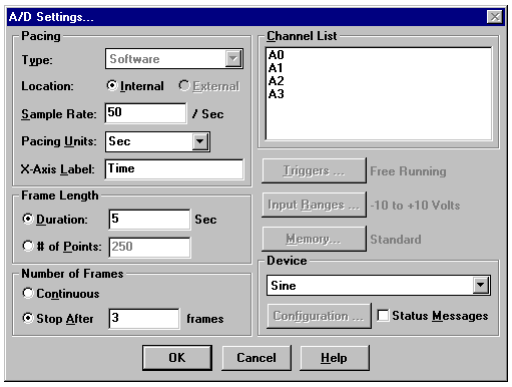


Figure 2-18 A/D Demo Settings

1. If the instrument EXAMPLE1.INS (or the file name you gave the instrument) is not open in the workspace, open it using the File menu, Open Instrument command.

2. Open the A/D Demo Settings dialog box by double clicking on the A/D Demo element icon in the instrument.

3. Double click in the Sample Rate field to highlight the current value, then type 50.

The Sample Rate of the A/D Demo element defines how many times per second a sample is taken. In other words, the sampling rate represents the number of data points per second for your instrument.

Changing the Frame Length

In addition to the Sample Rate, we can specify the length of each data frame in either seconds or as the number of points. For normal sampling with Time as the X-axis, the number of points per frame equals the sample rate multiplied with the frame length in seconds. For this example, we will specify the length using the time field.

1. Select the Duration radio button in the Frame Length group.

2. Double click in the Duration field to highlight the current value, and enter 5.

This setting makes each frame five seconds long. If you select another item in the dialog either by clicking on it or by pressing TAB, notice that the # of Points entry is automatically recalculated.

Stopping the Instrument Automatically

In the previous example, you had to manually stop the instrument using the Stop button or menu command. This section will automatically stop the instrument after three frames of data have been processed.

1. Select the Stop After radio button in the Number of Frames group.

2. Double click in the Stop After field to highlight the current value, and enter 3.

   This setting automatically stops the instrument after collecting three frames of data.

4. Press the OK button to accept the changes.

5. Save the instrument with the button or select the File menu, Save Instrument command.

Running the Instrument

1. Press the

button or the Start! menu command.

   If you allow the instrument to run its complete course, it should stop after the third frame of data. Notice that the X-Axis labels in the Display window constantly reset themselves to represent the frame time and not the elapsed test time. In addition, the frame number appears in the upper right corner of the plots to indicate the current frame for the data being displayed.

Chapter 3. Display

3.1. Display Window..... 3-1
3.2. Plot Types 3-3
3.3. Menu Commands.....3-16
3.4. Tutorial: Changing the Display Settings.....3-28
3.5. Tutorial: Using Display Pages.....3-36
3.6. Tutorial: Using Cursors And Markers 3-38

The Display element allows data from other elements to be viewed on the computer monitor. Data from multiple channels and sources can be displayed simultaneously, using overplotting or using multiple on-screen axes. In addition, you can print the contents of the current display page or the entire desktop directly from this window. The Display window appears on screen when you double-click on the Display element icon or when you start the instrument.

3.1. Display Window

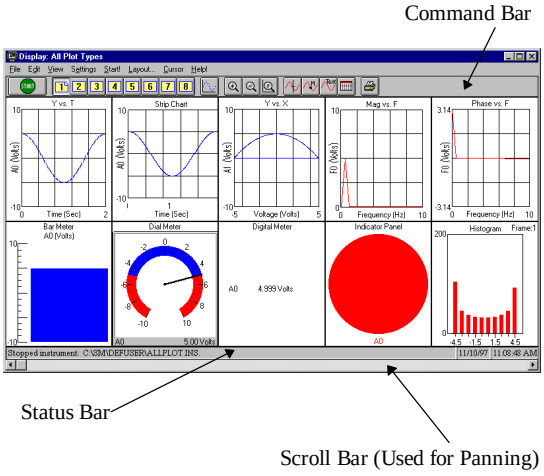


Figure 3-1 Display Window

Command Bar

The Display window's Command Bar contains the following special buttons for commonly used Display menu commands:

Button	Description
	Starts or Stops the instrument.
	Changes to the specified Display page.
	Redraws the data in the plots.
	Zoom in both X and Y axes.
	Zoom out to previous level.
	Automatically rescale the Y-axis.
	Place a new data cursor.
	Place a new data marker.
	Place a new text annotation.
	Show or hide the Cursor Data table.
	Print the current Display Page to the default printer.

Scroll Bar

The Scroll Bar is used to pan through selected plots. For example, if you have a 10 second frame and the plot shows from 0 to 1 seconds, you can use the scroll bar to view 1 to 2 seconds, 3 to 4 seconds, etc. To select the plots controlled with the Scroll Bar, highlight them by holding the CTRL key and clicking the mouse on the plots, then use the Scroll Bar to move around in the frame.

3.2. Plot Types

Snap-Master's plot types can be broken down into related categories, with subtle differences between each different plot type. Use these categories to decide what type of plot to use.

Category	Plot Type	Special Features
Time Domain	Y vs. T	Log Plots, Sweep Graphs
	Strip Chart	Simulates moving paper
Frequency Domain	Mag vs. F	Plot Magnitude vs Frequency
	Phase vs. F	Plot Phase vs Frequency
Channel vs. Channel	Y vs. X	Use channel data as X-axis
	Scatter	Points not connected by line
Single Value	Digital Meter	Visual alarms, display value
	Indicator	Visual alarms
	Bar Meter	Include custom pictures
	Dial Meter	Simulate analog gauges
Histogram	Histogram	Plot event counting data

To customize the appearance of any plot, click on the plot with the right mouse button. A popup menu lets you select the area of the plot you want to change. You can also double click in the center of the plot to open the Plot Settings dialog box. (If you have any cursors or markers on the plot, you must hold down the Shift key and double click the mouse). To change the appearance of this and other plots in the Display Layout dialog box, select the plot (or plots) you want to alter and press the Plot Settings button. To gain quick access to only the X-axis Settings or the Y-axis Settings, you can also double click on the appropriate axis.

Default Plot Templates

Each plot type has a default template that consists of all settings for the plot, except for the channels assigned to the plot. These settings include the channel colors, line styles, X and Y axis settings, plotting techniques, fonts, etc.

To make the settings for an existing plot the default, click on the plot with the right mouse button and select the Save As Default command from the pop-up menu. To apply the current default settings for the plot type to a plot, right click on the plot and select the Apply Default menu command. To automatically apply the defaults each time you create a plot in the Layout, turn on the Apply Defaults For New Plots check box in the Default Settings dialog.

Note that there is only one default template for each plot type, and the template settings from one plot type can not be applied to another plot type.

Y vs. T Plots

Displays the data from left to right with a stationary X-axis based on time. For time channels with more than one point per frame, Y vs. T is the default plot type for the Auto Layout function. This is the best general purpose display type, and is best suited for display during both data acquisition and replay.

Plot Settings

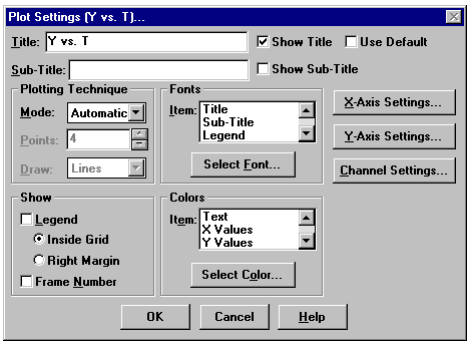


Figure 3-2 Plot Settings (Y-T)

Title

Each plot can have up to 2 rows of text for a Title. The main title of the plot is located in the Title field, and is the same as the title in the Display Layout table. For time domain plots, the Default title consists of the Channel Number (or Label) vs. Time. The Sub Title field lets you enter additional text that appears on a line between the title and the plot grid.

Plotting Techniques

Snap-Master includes several Plotting Techniques which can improve the performance of the Display window by changing the number of points actually plotted on screen. If you are not acquiring data at high speeds or plotting large numbers of data points, you may not need to use the plotting enhancements.

The most important item to remember when using the plotting techniques is that they only affect the output on the screen; all data is available to any elements that are after the Display element. Cursors and markers also follow the original data. This means that all of the original data remains intact, regardless of the plotting technique used.

Plotting data on the computer monitor requires many calculations, which is one of the reasons a math coprocessor is highly recommended, and a Windows video accelerator card should be considered for demanding plotting applications.

Because the plotting techniques "subsample" the incoming data, it is possible to create a "visual aliasing" effect. Make sure that you plot enough data points to show an accurate representation of the signal. For more information on aliasing, refer to Appendix C.

The different plotting techniques are:

Mode	Description
All Points	The most complete plotting technique which plots every data point. While this approach is excellent for slow moving data with relatively few data points or for replaying data from disk, it can tend to impede performance during acquisition when more points need to be plotted.
Skip	Plots every *nth* point, where the number of points skipped is specified in the Points field. You can specify whether to draw just the data points using the Draw Points option, or to connect the data points using Draw Lines.

Average	Averages every *n* points and plots the average value, where the number of points skipped is specified in the Points field. You can specify whether to draw just the data points using the Draw Points option, or to connect the data points using Draw Lines.
Automatic	Finds the minimum and maximum values in successive blocks of *n* points and draws a vertical line between the two points. The number of points in each block is calculated based on the current resolution of your video (i.e. 800x600, which is measured in pixels).
Min/Max	Finds the minimum and maximum values in successive blocks of *n* points and draws a vertical line between the two points. The number of points in each block is specified in the Points field.

Show

Each plot may contain its own Legend, located either inside the plot grid or in the right margin outside the grid. If the Legend is located inside the grid, it can be moved freely within the grid. If it is located in the margin, the Legend cannot be moved.

When Frame Number is selected, it appears in the upper right corner of the individual plot window.

Fonts And Colors

Different elements of each plot can have unique Font and Color settings. To change from the current setting, select the item from the provided list and press the appropriate button. The standard Windows dialogs for each item appear on screen.

X-Axis Settings

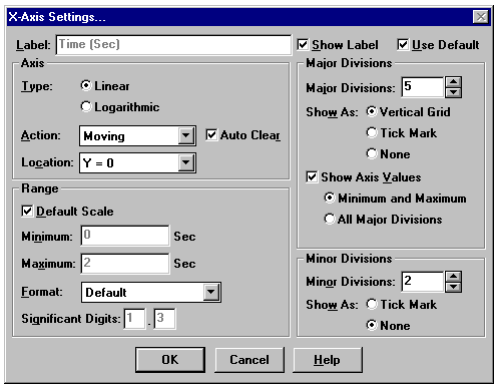


Figure 3-3 X-Axis Settings (Y vs. T)

Label

You can define the label shown along the X-axis using either the default, or by turning off the Use Default check box and entering a custom label in the field. If you do not want to show a label at all, turn off the Show Label check box.

Axis

Type — Determines if the axis scale is either Linear or a Logarithmic (base 10).

Action — Determines how the axis behaves when using the Linear axis and the Default Scale check box is turned off. **Moving** mode waits until the Minimum value is reached, plots the time between the Minimum and Maximum, then clears the graph and displays each increment thereafter. **Stationary** mode displays only the time between the Minimum and Maximum values. **Sweep** mode uses the same time increment, except that it does not clear the graph before plotting the new data.

Auto Clear — When selected, the Display clears the plot window each time a new frame begins. If you want to overplot the contents of multiple frames, turn off the Auto Clear check box. When Auto Clear is turned off the plot mode is Stationary, so only the data in the range set by the Minimum and Maximum is shown.

Location — Defines where the X-axis is drawn relative to the Y-axis. By default, the X-axis is drawn so it crosses the Y-axis at **Y = 0**. **Y Min** draws the X-axis at the bottom of the plot with the values and ticks below the axis. **Y Max** draws the X-axis at the top of the plot with the values and ticks above the axis. **None** means the X-axis is not drawn at all.

If your Y-axis range does not include 0, you may see tick marks extending beyond the plot boundaries (especially if the Axis Location is set to Y = 0). To correct this, select a different Axis Location.

Range

Sets the times displayed in the plot and the format of the axis labels.

Default Scale — When selected, the Minimum and Maximum settings are configured to show the entire data frame for the first channel defined in the Display Layout.

Minimum / Maximum — Sets the start and end time for the X-axis. Remember that for Moving mode, the difference between the Maximum and Minimum is used to set the increment amount.

Format — Specifies how the time labels are displayed. The **Default**, **Scientific** (1.00e+03), **Engineering** (1K), and **Fixed** (1000.000) formats display the relative frame time along the axis. **Significant Digits** set the number of digits on either side of the decimal point.

The **Time Of Day (12 hr)** and **Time Of Day (24 hr)** formats show the "wall clock" time of the frame. Times are entered as hr:mm:ss, with and AM or PM radio button for the 12 hour format. When the Time Fraction checkbox is selected, the fractional portion of the seconds is shown.

When you plot data that was acquired using Pre-Triggering, the actual trigger point is located at time "0" on the display. Any pre-trigger data appears before time 0. This works either with data coming directly from the acquisition element or from a data file read by the Disk In element.

Major Divisions

Major Divisions — Defines the appearance of the values, grid lines, and tick marks on the plot. The major divisions are spaced equidistantly from the Axis Location.

Show As — **Vertical Grid** displays a line across the entire plot region at each major division. **Tick Mark** shows only a small line along the axis at each major division. **None** does not display the locations of the major divisions.

Show Axis Values — When selected, displays the value at either the **Minimum and Maximum** of the axis, or at **All Major Divisions**.

Minor Divisions

Minor Divisions — Defines the number of subdivisions for each major division.

Show As — **Tick Mark** shows a small line along the axis at each minor division. **None** does not display the locations of the minor divisions.

Y-Axis Settings

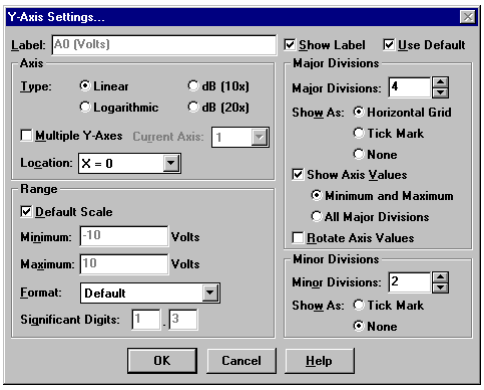


Figure 3-4 Y-Axis Settings (Y vs. T)

The Y-axis Settings are similar to the X-axis Settings, and are accessed by double clicking on the Y-axis area of the plot. Most of the controls are the same, except they control the Y-axis.

Axis

Type — Determines if the axis scale is either Linear, Logarithmic (base 10), dB (10x) or dB (20x). These Decibel options create Bode plots by taking a Logarithmic plot and multiplying it by the scale factor shown (either 10 or 20). The reason there are two options given is that different disciplines use different scaling factors for Bode plots.

Multiple Y-Axies — When selected, you can overplot data from different channels with different Y-axis scales. The number of axes in the list is the same as the maximum number of channels you can assign to a plot. As you select an axis in the Current Axis, the Y-axis settings change to the ones used for that axis. The final step is to assign a channel to a specific axis using the Channel Settings dialog box.

Major Divisions

Rotate Axis Values — Allows you to turn the values on the Y-axis sideways so they read vertically up the screen, as opposed to horizontally across the screen. Usually works best with True Type fonts.

Channel Settings

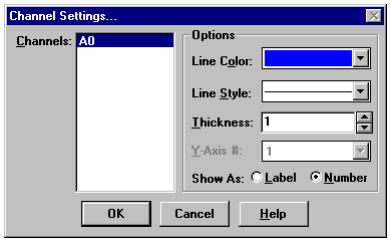


Figure 3-5 Channel Settings (Y vs. T)

The Channel Settings dialog sets the colors and line style of the channels within a plot. If the plot type supports multiple Y-axes, this dialog also assigns each channel to an axis.

Channels — The channels highlighted in the list are being edited in the Options group.

Line Color — Specifies the color of line used for the selected channels.

Line Style — Specifies the type of line used for the selected channels. If you select a dotted style, the dots may appear to be connected together due to the high resolution of plotting in Snap-Master. To make the different styles appear more distinct, try changing the X-axis Minimum and Maximum values.

Thickness — Specifies the width of the line used for the selected channels. Higher thickness values tend to slow the performance of the Display.

Y-Axis #: — If Multiple Y-Axes is selected in the Y-Axis Settings dialog, specifies which Y-axis the selected channels are assigned to.

Show As — Specifies if the channels are shown by **Label** (if assigned using the Sensor or Analysis element) or the channel **Number** (consisting of the element letter and channel number). This setting is also reflected in the Channel list.

Strip Charts

A Strip Chart plot simulates the action of a paper roll strip chart recorder. The "paper" scrolls from right to left, with new data plotted at the right edge. Strip chart mode is most useful for lower speed data acquisition. When you are acquiring data at speeds where the strip chart appears to flicker too much, use the various Plotting Techniques to increase the plot's throughput and improve the "smoothness" of the strip chart.

Other than the on screen appearance of the data, Strip Chart plots have the same features as Y-T plots and use the same Plot Settings, X-Axis Settings, Y-Axis Settings, and Channel Settings dialogs. There are certain features not available for the Strip-Charts which are disabled in the dialogs. To use these features, change the plot type to a Y-T plot.

Frequency Plots (Mag vs. F, Phase vs. F)

Frequency domain plots operate the same as Time domain plots, except the X-axis is now expressed in the frequency units Hertz (Hz). Mag vs. F plots the magnitude of the frequency component relative to the frequency, and Phase vs. F plots the phase at each frequency between plus and minus pi.

The Plot Settings, X-Axis Settings, Y-Axis Settings, and Channel Settings dialogs for frequency domain plots function the same as the dialogs used for Y-T plots. Because the X-axis basis is different, you cannot overplot time domain with frequency domain data.

Y vs. X, Scatter Plots

The Y vs. X and Scatter plot types are similar to the time domain plots, except that they use an input channel as the basis for the X-axis. These plot types are considered to be a time domain plots because all channels have the time variable in common.

Y-X plots use the same Plot Settings, Y-Axis Settings, and Channel Settings dialogs as Y-T plots.

X-Axis Settings

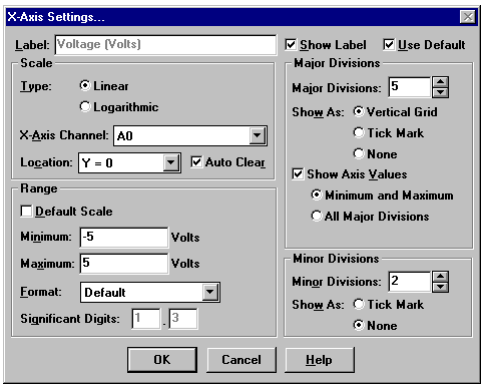


Figure 3-6 X-Axis Settings (Y vs. X)

Axis

X-Axis Channel — Defines the channel used for the basis of the X-axis. Each channel specified in the Display Layout table is plotted against the X-Axis Channel using the same time reference (the value of the channel at time *t* versus the value of the X-Axis Channel at time *t*).

Digital Meters

The Digital Meter plot type is also a time domain plot, but only one data point is displayed at a time. This plot type is useful for data that does not change rapidly (such as temperatures) or statistical values from the Analysis element. For time channels with only one point per frame, Digital Meter is the default plot type for the Auto Layout function.

Digital Meter Settings

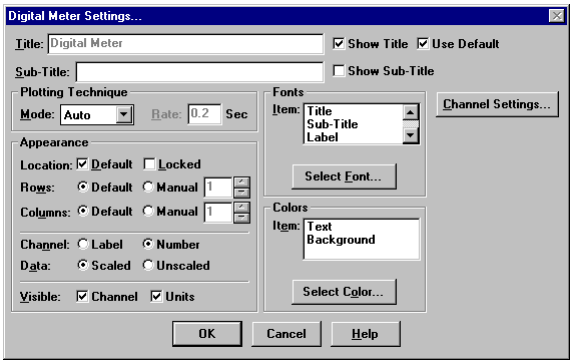


Figure 3-7 Digital Meter Settings

Plotting Technique

Mode — **Auto** mode displays the most recent data value when an update occurs. **Interval** displays the data at every time interval specified by the Rate setting (similar to the Skip mode for a Y-T plot). **Average** displays the average data value for all points in the previous interval.

Rate — Specifies the update rate for the digital meter in seconds. Similar to the Points setting for a Y-T plot.

Appearance

Location — The **Default Location** check box automatically places the Channel to the left of the value, and the Units to the right of the value. When the Default Location check box is turned off, you can move and size each object by clicking and dragging the object within its plot region.

Once you have positioned the objects where you want them, you can disable further movement by turning on the **Locked** check box.

NOTE: If the Default Location check box is turned off and you add more channels to the Digital Meter plot from the Display Layout table, the new channels may not appear until you turn the Default Location check box back on.

Rows — Specifies the number of rows used in the digital meter for multiple channels. When **Manual** is selected, enter the number of rows desired.

Columns — Specifies the number of columns used in the digital meter for multiple channels. When **Manual** is selected, enter the number of columns desired.

Channel — Specifies if the channels are shown by **Label** (if assigned using the Sensor or Analysis element) or the channel **Number** (consisting of the element letter and channel number).

Data — Specifies if the data is **Scaled** (with any Factor and Offset applied to the data) or **Unscaled**

Visible — Specifies if the **Channel** and / or **Units** portions of the digital meter are displayed. The data value is always shown.

Fonts And Colors

Fonts and Colors operate the same for Digital Meters as for Y-T plots, with one exception. The Background color applies only to the visible title lines in the plot, because each channel has a programmable color background (which is set in the Channel Settings dialog box).

Channel Settings

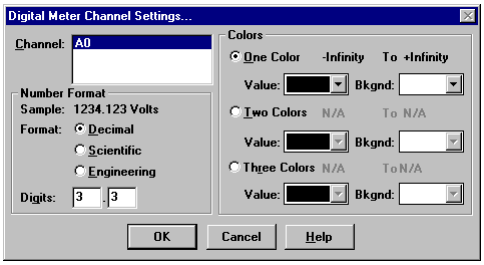


Figure 3-8 Digital Meter Channel Settings

The settings are separate for each channel in the Channel list. You can change the settings for multiple channels by highlighting more than one item in the Channel list.

Number Format

Format — Specifies if the values are displayed as a **Decimal** (1234.123), **Scientific** (1.234e+03), or **Engineering** (1.234 K) number

Digits — Specifies how many numbers are displayed before and after the decimal place.

Colors

One Color — Specifies the value and background colors for the selected channels for the range specified. When One Color is selected, the same colors are used for all data values.

Two Colors — When selected, the cutoff value for the visual alarm is entered at the end of the One Color line. All data values up to the cutoff value are set by the One Color settings, and all data values above the cutoff value are set by the Two Color Settings.

Three Colors — When selected, the cutoff values for the visual alarm are entered at the end of the One Color and Two Color lines. These Three Color settings determine the colors used for the specified range of values.

Indicators

The Indicator plot type simulates a status lamp or an LED to represent relative values. This plot type is well suited for visual alarms because you can set up each indicator to have multiple colors for the indicator and the background based on the current value.

Indicator Settings

The majority of the Indicator Settings operate the same as a Digital Meter. Each indicator can be moved and sized within its own region when the Default Location is turned off. A new **Shape** control lets you select the shape of the Indicator as either an **Ellipse** or a **Rectangle**.

Channel Settings

The Channel Settings uses the same visual alarm color settings used by the Digital Meter plot type.

Bar Meters

Bar Meter plots display single values using a vertical or horizontal colored bar. This plot type is useful for data where the value is best displayed in relation to its overall value. The bar meter can be customized by including user defined pictures directly in the display.

Bar Meter Settings

The majority of the Bar Meter Settings operate the same as the equivalent settings for a Digital Meter. Fonts and Colors operate the same for Bar Meters with one exception: the Background color sets the color for the background of all default bar plots. If a user defined picture is included, the Background color setting does not change the background color of the picture as it appears in the Display.

Axis Settings

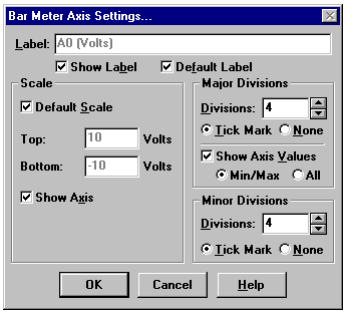


Figure 3-9 Bar Meter Axis Settings

Even though the bar meter displays a single value, it does so in relation to an axis. The Bar Meter Axis Settings dialog operates in the same fashion as the X-Axis or Y-Axis Settings for a Y-T plot. The direction of the bar meter (which is set in the Picture Settings dialog) determines if the scale is measured from Top to Bottom (Vertical) or Left to Right (Horizontal).

Channel Settings

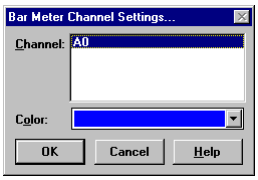


Figure 3-10 Bar Meter Channel Settings

The Channel Settings for a bar meter defines the fill color for the bar. There are no alarm conditions for the bar meter, so only one color needs to be defined (if you want to include special alarm displays in a bar meter, try including them in a user defined picture). Any channels highlighted in the Channel list are set to the selected Color, and you can set multiple colors simultaneously by selecting more than one channel from the list.

Picture Settings

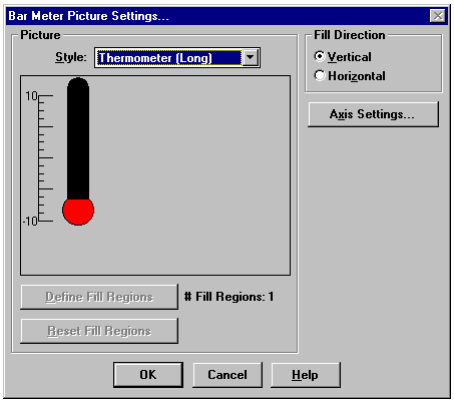


Figure 3-11 Bar Meter Picture Settings

One unique feature of bar meters is the ability to use a picture to define how the bar meter appears on screen. The Bar Meter Picture Settings dialog box lets you change the appearance of the bar meters by including either a default or a custom picture. The Picture Style lists the default pictures available in Snap-Master, as well as the “(None)” (which uses just a normal rectangular bar) and “User Defined...” options.

When including a User Defined picture in the bar meter, you must define the Fill Regions for the picture. This is where Snap-Master actually draws the bar graph in. The region can be any shape, as long as there is a complete outline of black to define the boundaries. For example, the pictures shown in 3-12 illustrate the correct way to create a proper fill boundary. The picture on the left contains a solid boundary, while the picture on the left has an “open” space where the boundary of black is broken.

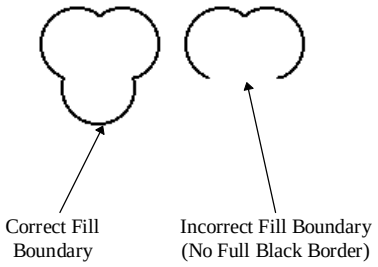


Figure 3-12. Correct and Incorrect Fill Regions for Bar Meters

To define the fill regions, click on the Define Fill Regions button. Move the mouse pointer into the region where you want the bar meter drawn, and click the mouse button. To fill more than one area, continue clicking in the desired fill regions. When you are done, press the Exit Define Fill Regions button.

The Fill Direction setting determines how the bar meter moves in relation to the screen. When Vertical is selected, the boundaries in the Axis Settings dialog define the Top and Bottom values. For Horizontal, the boundaries define Left and Right.

Dial Meters

Dial Meter plots display single values using a familiar “needle and gauge” type display. This plot type is useful for data where the value is best displayed in relation to its overall range, or when users want the familiar analog gauge look. Alarm conditions are indicated by the color bands on the dial itself.

Dial Meter Settings

The majority of the Dial Meter Settings operate the same as the equivalent settings for a Digital Meter. The Channel, Value, and Units are displayed in the bezel underneath the dial meter to show not only the relative value but the actual data value as well. The resolution of the Value is fixed to show two numbers after the decimal (for more control over the display of the values, try using a Digital Meter plot type).

Fonts and Colors operate the same for Dial Meters as for Digital Meters, with one exception. The Background color sets both the back color for the plot as well as the colors of the virtual meter’s bezel. The bezel colors are automatically set to contrast with the Background color so the bezel is always visible.

Channel Settings

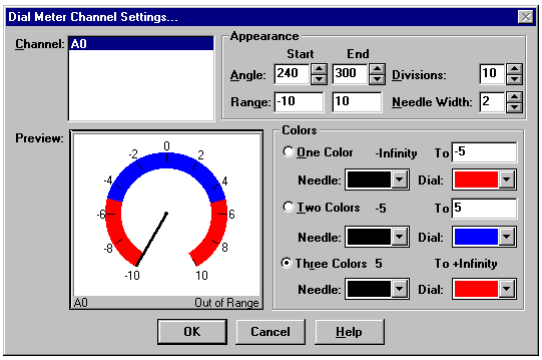
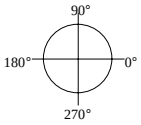


Figure 3-13 Dial Meter Channel Settings

Appearance

Angle — Defines the **Start** and **End** angles for the dial meter, which range from 0 degrees to 360 degrees.



Divisions — Specifies how many ticks appear in the meter, and also defines where the meter values are displayed.

Range — Specifies the corresponding data values for the **Start** and **End** angles.

Needle Width — Specifies the width of the needle.

Colors

Uses the same visual alarm methodology as the Digital Meter color settings by allowing up to three different color sets for the **Needle** and **Bar** on the dial meter.

Histogram Plots

Histogram plots are used in conjunction with the Histogram element to display data in terms of "event bins" instead of simply events. Like the other plot types in Snap-Master, the histogram plot is updated as the data comes into the instrument. When the Histogram element is included in the instrument, the Plot Type is automatically configured as a Histogram plot.

Plot Settings

Figure 3-14 Histogram Plot Settings

The Plot Settings for the Histogram plot are similar to a Y-T plot, with the addition of the X-Axis Settings and Y-Axis Settings to set the labels and ranges of data displayed.

Channel Settings

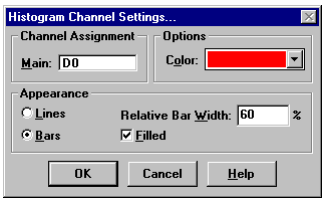


Figure 3-15 Histogram Channel Settings

Main	Specifies the Histogram channel being plotted
Color	Specifies the color used for the data
Appearance	The **Lines** option plots thin vertical lines for each bin. The **Bars** option uses the **Relative Bar Width** value to determine the width of the bars (100% fills the entire bin space, less than 100% leaves space between each bin)
Filled	When selected, the bars are filled with the Color. When not selected, only the outlines of the bars are drawn or the lines are connected.

3.3. Menu Commands

File Menu

Please refer to Chapter 2 for a description of the common menu commands.

Print Display

Immediately prints the current Display page using the default settings. Using the keyboard, press CTRL+P to perform this command.

Print Setup

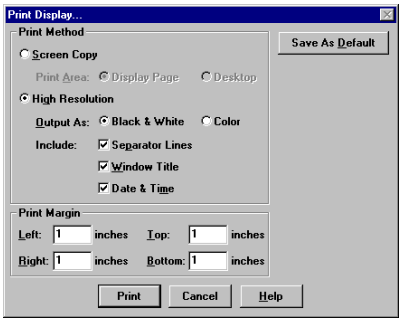


Figure 3-16 Print Display Settings

Print Method

Screen Copy	Prints a bitmap image of either the current **Display Page**, or the entire **Desktop** (useful for including the Cursor Data window or the workspace). The resolution of this printout is the same resolution as your display (which is approximately 72 dots per inch).
High Resoultion	Prints the current Display Page using the actual resolution of the printer, as either **Black & White** (all data printed in black against a white background) or **Color** (using the colors as they appear on screen). In addition, the printout can contain **Separator Lines** between plots, the **Window Title** for the Display Page, and the current **Date & Time**.

Print Margin
Sets the respective margins (in inches) for the printout.

Save As Default
The Save As Default button allows you to store the current Print Display settings as defaults. These defaults are used each time a new Display element is included in an instrument and when the user presses the button from the Display window's command bar.

Edit Menu

Copy Once the Display looks the way you want, you can make a bitmap copy of the Display window image and paste it into other Windows programs. In fact, this User's Manual was created by copying various parts of the Snap-Master program and pasting it directly into a word processor.

These instructions give a quick example of how to use copy the Display window picture to the Clipboard, then paste the contents of the Clipboard in the Paintbrush program supplied with Windows.

- Select the Display window's Edit menu, Copy command.
- Run the Paintbrush program.
- Select the View menu, Zoom Out command. This allows the full picture to appear in the window.
- Select the Edit menu, Paste command.

  A cross-hatch pattern appears that represents the size of the image on the Clipboard. To reposition the picture, drag it around the page.
- Select the Edit menu, Paste command. This second Paste command places the contents of the Clipboard into the cross-hatch area. (This is a special command for Paintbrush only).

View Menu

Command Bar Turn the Display Command Bar on or off.

Status Bar Turn the Status Bar on or off.

Scroll Bar Turn the Display Scroll Bar on or off.

The Scroll Bar is used to pan through selected plots which are showing only a portion of the frame. To select the plots controlled with the Scroll Bar, highlight them by holding the CTRL key and clicking the mouse on the plots, then use the Scroll Bar to scroll through the frame.

Display Page Each Display window has up to eight display pages, which are accessed using the Pages menu. The pages are configured using the Layout dialog, which defines the plot types for each page. For keyboard users, pressing the ALT key along with a number changes to that page.

You can change the display page while the instrument is running, but only the only data processed after the page change is plotted. All plots on the current page are refreshed at the next frame boundary.

Zoom In

Lets you specify the exact area you want to zoom in on. After you select a Zoom In mode, the mouse pointer changes to .

To specify the area you want to zoom in on, draw a rectangular box around the area by holding down the right mouse button and dragging the cursor with the mouse. When you release the mouse button, the minimum and maximum values for the axes you specified change to match the coordinates of the zoom region, and the updated Display appears. (If the data does not redraw in the new axis ranges, make sure you have Auto Retrace selected or press the Retrace button in the command bar.

If the plot you zoom in on belongs to a linked zoom group (which is set in the Layout), all plots in that group will zoom in to the same X- and Y-axis range.

X- And Y- Axis

Changes the ranges on both the X-axis and the Y-axis. Pressing the button in the command bar zooms in both the X and Y axes.

X-Axis

Changes the range on the X-axis only. The Y-axis range remains constant.

Y-Axis

Changes the range on the Y-axis only. The X-axis range remains constant.

Zoom Out

Lets you restore the axis ranges to a previous setting. After you select a Zoom Out mode, the mouse pointer changes to .

Select the plot you want to zoom out by positioning the mouse pointer over the Display region and pressing the right mouse button. Snap-Master remembers the last five zoom levels, so you can move between resolutions to see your data more clearly.

If the plot you zoom out on belongs to a linked zoom group (which is set in the Layout), all plots in that group will zoom out to the same X- and Y-axis range.

Previous

Restore the X-axis and Y-axis ranges to the values used before the previous Zoom In command. Pressing the button in the command bar zooms out to the Previous range.

Original

Restore the X-axis and Y-axis ranges to the values used when the instrument was last started.

Zoom Auto Scale

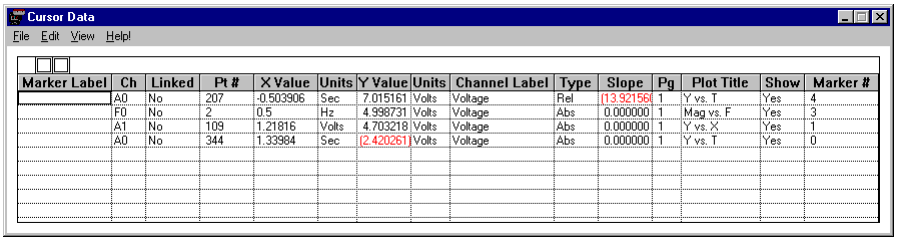
The Auto Rescale function is a special type of Zoom In command that resets the Y-axis range so that all data in memory can be shown in the plot. The Auto Rescale function scans through the available data in the plot (depending on the Retrace Mode) and resets the Y-axis so the minimum and maximum values are shown.

After you select the Auto Rescale mode, the mouse pointer changes to . Select the plot you want to rescale by positioning the mouse pointer over the Display region and pressing the left mouse button. (Remember that the Retrace Mode affects the ranges displayed because each mode addresses a different amount of data.)

Retrace Now!

Refresh the data on the current Display page using the current retrace mode, which is selected in the Settings menu.

Cursor Data



Marker Label	Ch	Linked	Pt #	X Value	Units	Y Value	Units	Channel Label	Type	Slope	Pg	Plot Title	Show	Marker #
	A0	No	207	-0.503906	Sec	7.015161	Volts	Voltage	Rel	[13.92156]	1	Y vs. T	Yes	4
	F0	No	2	0.5	Hz	4.998731	Volts	Voltage	Abs	0.000000	1	Mag vs. F	Yes	3
	A1	No	109	1.21816	Volts	4.703218	Volts	Voltage	Abs	0.000000	1	Y vs. X	Yes	1
	A0	No	344	1.33984	Sec	[2.420261]	Volts	Voltage	Abs	0.000000	1	Y vs. T	Yes	0

Figure 3-17 Cursor Data Window

The Cursor Data table opens when you place a new cursor or marker in the Display window. It can also be opened and closed using the button in the Display window command bar.

There are two places where the Cursor Data table appears: in the Display window or in its own window. To change the window where the table appears, right click over the table and select Toggle Location from the pop up menu. When the table is in the Display window, it appears below the Command Bar and above any plots (which are resized to fit the additional window). When the table is in its own window, that window will always appear on top of the Display window, and it can be repositioned anywhere on the screen.

The following list describes each of the columns in the Cursor Data window.

Column	Description
Marker Label	The name of the marker. For cursors, this field is blank.
Ch	The channel associated with the cursor or marker.
Linked	Specifies the linked cursor or marker group for this item. Up to 8 link groups can be defined. When any cursor or marker included in this group is moved, all cursors and markers in this group moved according to the Cursor Link Movement setting, which is set in the Cursor Data Window Settings dialog.
Pt #	The location of the current data point in relation to the frame. You can poke these values to the Cursor Data table using DDE.

X Value	The X-axis value of the current data point. You can poke these values to the Cursor Data table using DDE.
Units	The X-axis units of the channel.
Y Value	The Y-axis value of the current data point.
Units	The Y-axis units of the channel.
Channel Label	The label of the channel which the cursor or marker is tracking.
Type	For a cursor, lists either "Abs" (for Absolute) or "Rel" (for Relative). For a marker, lists "Mrk".
Slope	For relative cursors, the slope between the two cursors. For markers and absolute cursors, the value is 0.
Pg	The Display Page of the plot associated with the cursor or marker.
Plot Title	The title of the plot associated with the cursor or marker.
Show	Specifies if the cursor or marker is visible in the plot. The available options are "Yes" and "No". You can poke these values to the Cursor Data table using DDE.
Marker #	The number of the cursor or marker. This number is referenced in the DDE Link. Refer to Appendix D for more information.

Settings Menu

Auto Retrace

Turn the Auto Retrace function on or off. Each time the Display window is refreshed, the current Retrace Mode (Buffer Retrace or Full Retrace) is used to redraw the data.

Auto Layout

Automatically arrange the Display plots according to the Auto Layout settings in the Display Defaults dialog box.

Display Settings

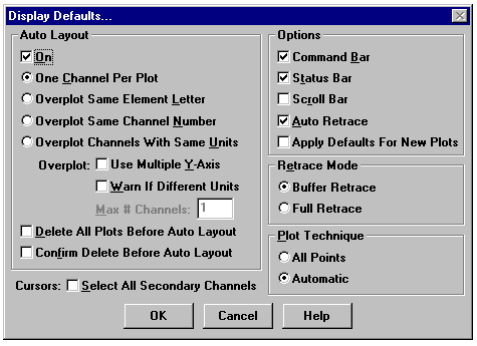


Figure 3-18 Display Defaults

The Display Defaults are used each time you include a new Display element in an instrument. These settings do not prohibit you from changing these settings in each plot, they only provide you with a customized starting point.

Auto Layout

On	Auto Layout function is enabled.
One Channel Per Plot	Create a separate plot for each channel.
Overplot Same Element Letter	Overplot channels from the same element letter
Overplot Same Channel Number	Overplots channels from different element letters with the same channel number
Overplot Channels With Same Units	Overplots channels with the same units
Use Multiple Y-Axes	When overplotting, create a separate Y-axis for each channel.
Warn If Different Units	When using the Overplot Same Element Letter and Overplot Same Channel Number modes, you are informed that channels with different units are being plotted on a single set of axes.
Max # Channels	Sets the maximum number of channels assigned to a single plot.
Delete All Plots Before Auto Layout	Clears the contents of the Display Settings table before performing the Auto Layout.
Confirm Delete Before Auto Layout	Asks you if you want to delete all existing plots before performing the Auto Layout.

Cursors

Select All Secondary Channels	When selected, each new cursor displays all channels in the Cursor Data window. When turned off, only the primary channel is displayed.

Options

Command Bar Status Bar Scroll Bar	When selected, the item is visible by default.
Auto Retrace	When selected, Auto Retrace is enabled by default.
Apply Defaults For New Plots	When selected, the default plot template settings are applied to all new plots created in the Layout.

Retrace Mode

The selected mode is used when a new Display element is included in an instrument.

Plot Technique

The selected mode is used when a new Display element is included in an instrument.

Status Bar Settings Open the Status Bar Settings dialog box. Operates the same as the Status Bar settings dialog in the Snap-Master workspace.

Cursor Data Table

When you right click over the Cursor Data table, the pop up menu contains a Settings command. Selecting this menu command opens the Cursor Data Window Settings dialog.

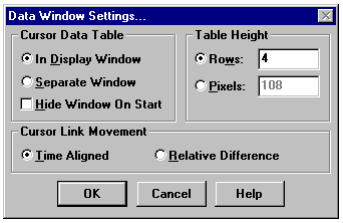


Figure 3-19 Cursor Data Window Settings

In Display Window	Shows the Cursor Data table in the Display window below the Command Bar and above any plots.
Separate Window	Shows the Cursor Data table in its own window, which always appears on top of the Display window.
Hide Window On Start	When selected, the Cursor Data table is hidden when the instrument is run. When turned off, the table remains visible.
Table Height	Sets the amount of space allocated for the table. When the table is shown in its own window, that window is sizable.
Cursor Link Movement	Determines if linked cursors and markers move **Time Aligned** (using the same X-Axis value for all linked cursors and markers) or **Relative Difference** (where the delta between X-Axis values is maintained as the cursors or markers are moved).

Retrace Mode

In the Display element, there are two Retrace Modes: **Buffer Retrace** and **Full Retrace**. A Buffer Retrace uses the data stored in the temporary data buffers used by Snap-Master. The size of this buffer depends on the element producing the data. For most acquisition elements (such as an A/D element), the buffer size is 16,384 aggregate points (divide by the number of channels). For the Disk In element, the buffer size is 4096 points. If the Analysis element is calculating values, the Block Size (located in the Element Parameters table) determines the buffer size.

For large data sets, especially from the Disk In element, the Full Retrace option is useful. Full Retrace goes out to the data file in Disk Out and essentially "replays" the data file to display the complete viewing area. Also, if the data is from an acquisition element, a different buffer is read that provides more data than the Buffer Retrace. The Analysis element only has the Block Size data stored in memory, so a Full Retrace for Analysis produces the same results as a Buffer Retrace.

The main drawback of the Full Retrace is that it is slower than a Buffer Retrace. Also, Analysis equations are not recalculated during a retrace, so the information in the Block Size is the only data available. In addition, you must start the instrument before you can perform a retrace.

Start Menu

Begin operation of the instrument. When the instrument is running, only a Stop! command appears in the menu. When the Display is the active window, pressing the SPACEBAR on the keyboard acts as a Start and Stop command.

Layout Menu

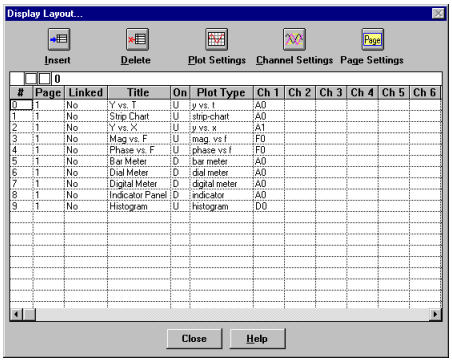


Figure 3-20 Display Layout

The Display Layout table defines the different plots used in the different pages, and which channels are assigned to the plots.

To use the Display Layout table, position the selection box on the field (or fields) you wish to change. Pull down the selection list located in the upper left corner of the table to view the available options. To select one of the available options, double click on it. The Title column does not have a selection list, so simply type the title for the plot.

The table allows you to make multiple selections by highlighting more than one cell at a time. When you make multiple selections, you are allowed to change parameters for more than one plot at one time. The table only allows you to select columns that make sense. For example, you can select multiple Channel selections, but you cannot select the Plot Type and Channel column. Use the mouse to click and drag the selections you want, or use with the CTRL key to make discontinuous selections.

Column	Description
#	Indicates the plot number used for DDE communication with the Display element. Refer to Appendix D for more information.
Page	Specifies the Display Page on which this plot appears. The N option means the plot is not shown.
Linked	Specifies the linked zoom group for the plot. When the plot is included in a link group and you zoom in on one of the plots included in the group, all plots zoom in to the same settings. Up to 8 zoom groups can be defined.
Title	Allows you to type your own title for a plot. Press the F2 key to edit the title.
On	Specifies the title used in the plot. "D" means the Default Title is used, "U" shows the User Defined Title, and "N" means that no title is shown.
Plot Type	Specifies the type of plot being used. If you assign a new plot type to channels with a different y-axis basis, (for example, changing the plot type to a Mag vs. F with time-domain channels specified), a message appears asking if you want to cancel the change or clear the channel list.
Ch 1 Ch 2... Ch 16	Specifies the channels to be overplotted on the same axes.

Insert Inserts a new table entry above the selected plot (or plots).

Delete Removes the selected plot (or plots) from the layout.

Plot Settings To alter the appearance of a specific plot, position the selection box on the plot you wish to change and press the Plot Settings button. The Plot Settings dialog that appears depends on the plot type of the row you selected.

Channel Settings To change the appearance of the channel colors and line styles, press the Channel Settings button.

Page Settings

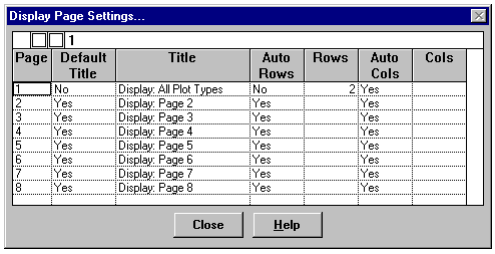


Figure 3-21 Display Page Settings

The Display Page Settings dialog defines the window titles for each Display page, and the number of rows and columns used for each page.

Column	Description
Page	Specifies the Display Page for these settings.
Default Title	Defines if the title for each Display page uses the Snap-Master defined name or the user defined name. When Default Title is Yes, the window is named “Display: Page #”, where the # is the page number. When Default Title is No, the contents of the Title cell defines the window name.
Title	User defined title for the page.
Auto Rows	When set to Yes, Snap-Master arranges each plot automatically to provide the maximum size for each set of axes. When set to No, the number of Rows specified is used.
Rows	User defined number of rows for the page. Entering a value here automatically changes Auto Rows to No. To have each graph appear in a single row, set the number of Rows to 1.
Auto Cols	When set to Yes, Snap-Master arranges each plot automatically to provide the maximum size for each set of axes. When set to No, the number of Cols specified is used.
Cols	User defined number of columns for the page. Entering a value here automatically changes Auto Cols to No. To have each graph appear in a single column, set the number of Cols to 1.

Cursor Menu

New Cursor

Cursors are used to view the actual data values for a specific point or the relative difference between two data points. When you are placing a cursor, the mouse pointer changes to . Move the center of the mouse pointer over the waveform you wish to place a cursor on, and press the mouse button. The data for the cursor appears in the Cursor Data window.

If the data you clicked on is not available in memory or from the Disk In element, try performing a Retrace Now with the button or change to Full Retrace Mode using the Options menu, Retrace Options command. Each plot can have multiple cursors, markers, and text annotations.

To move a cursor, click and hold the mouse button on the hot spot (indicated by a dotted outline around the selected cursor or marker) to drag the cursor across the waveform. In addition, the left and right mouse buttons move the cursor in the increments given by the Skip Rate value in the Setup dialog box. Clicking on the right mouse button moves the cursor in the positive X-axis direction, while the left mouse button moves the cursor in a negative X-axis direction. Holding the mouse button down will continue the movement of the cursor in the direction you have chosen.

You can link multiple cursors and markers together so they move in tandem using the Linked column in the Cursor Data table. Up to 8 link groups can be defined.

Cursor Settings

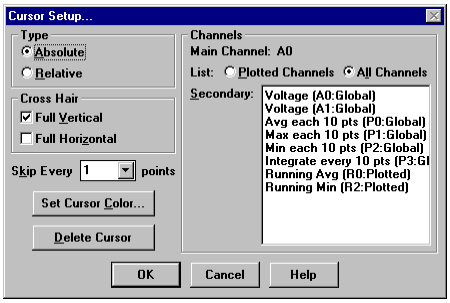


Figure 3-22 Cursor Setup Dialog Box

To configure a cursor using the Cursor Setup dialog box, double click on its hot spot.

There are two types of cursor: Absolute and Relative. An Absolute cursor (indicated by an (Abs) Type in the Cursor Data window) displays the current X-axis and Y-axis values at the cursor position in the Cursor Data window. A Relative cursor (indicated by an (Rel) Type in the Cursor Data window) displays the X- and Y-axis differences and the slope between two data points. In Relative cursor mode, the original cursor has anchors at the top and bottom of the vertical bar. When you click and drag the cursor hot spot, a new cursor appears with a line connecting the two cursors.

To change the appearance of the Cursor, you can specify the Cross Hair type. The Full Vertical option draws a line across the entire vertical (Y-axis) plane at the cursor location, and the Full Horizontal option draws a line across the entire horizontal (X-axis) plane. When both options are turned off, a short line is drawn at the cursor location.

The Skip Rate setting determines how many points are skipped when using the left and right mouse buttons to scroll through the data. The Cursor Color dialog box opens the Windows standard Color dialog, and allows you to set the color of the cursor. To delete a specific cursor, use the Delete Cursor button on the Cursor Setup dialog box.

The Channels group defines the Main channel, which is the channel where the cursor resides. Selecting additional channels from the Secondary list lets you see the corresponding Y-axis values for overplotted waveforms at the same X-axis value. The Secondary list shows either the Plotted Channels (those that are on the same plot) or All Channels (all channels coming in to the Display element). When Select All Secondary Channels is turned on in the Default Settings dialog for the Display, all channels are selected when you drop the cursor.

New Marker

Placing and using a marker uses similar procedures to a cursor. When placing a marker, the mouse pointer changes to

.

Markers are similar to cursors, except that instead of being able to view the relative difference between points a marker can have a text description of the point. The data for the marker appears in the Cursor Data window.

Marker Settings

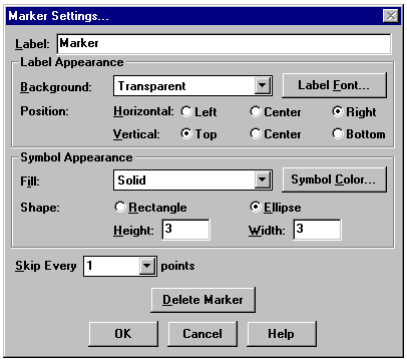


Figure 3-23 Marker Settings Dialog Box

The Marker Settings dialog box configures the appearance of both the marker symbol and the attached label. The Skip Rate and Delete Marker controls are the same as in the Cursor Setup dialog box, but each cursor and marker has its own settings.

The symbol's general appearance is controlled by the Symbol Settings group. The Appearance setting specifies how the marker looks: either as an Outline (where the symbol is only outlined), Solid (where the symbol is filled in), or None (the symbol does not appear). The Shape is either a Rectangle or an Ellipse, and uses the Height and Width (which are measured in screen pixels) to determine the size of the symbol. The Symbol Color button opens the Windows standard Color dialog, and allows you to set the color of the symbol.

The label for the marker is specified in the Label field. This can also be changed from the Cursor Data table. The Appearance settings for the label are Opaque (the grid lines and waveforms underneath the label are covered), Transparent (the grid lines and waveforms underneath the label are shown), and None (the label is not shown). The Position buttons specify where the label appears in relation to the symbol. The Label Font button opens the Windows standard Font dialog box, which sets the font and size of the label text. The label text color is set to the Window Text color specified in the Windows Control Panel

New Text

Text annotations allow you to include additional text information directly in the Display window. When placing a text annotation, the mouse pointer changes to Text.

Text annotations are similar to markers, except that there is no associated data point and the text can be placed anywhere within a plot window which will accept a cursor or marker. Because there is no data associated with the text, a corresponding item does not appear in the Cursor Data table.

Text Settings

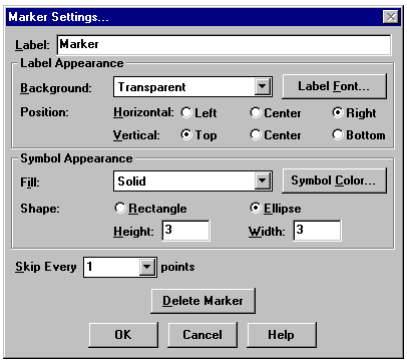


Figure 3-24 Text Settings Dialog Box

To edit the Text item, double click on it in the window so the Text Settings dialog appears. The Label, Appearance, and Label Font work the same as for a marker.

As part of the text item, you can include specific information about the elements in the Snap-Master instrument or information from another DDE enabled application.

To disable the DDE Request, select the None radio button. The Show check boxes determine if the name of the information is included in the label.

When Snap-Master is selected as the DDE source, use the Element list to see all of the elements included in the instrument. When you select an element, the available DDE parameters appear for the element (refer to Appendix D for more information on the available DDE Parameters for each element).

Using this mechanism, you can request information from any element, such as the data file name from a Disk In element, the Sample Rate for an A/D Board, etc. When you print the contents of the Display window, this information is included in the printout. Also, the Show Element and Show Parameter check boxes determine if the actual DDE Request information is included in the text annotation.

When another application is used for the DDE Request, you will need to fill in the Application, Topic, and Item edit controls with the DDE information you are requesting. Consult the manual for that application for details on requesting DDE data.

Clear All Cursors Clear all cursors in the Display.

Clear All Markers Clear all markers in the Display.

Clear All Text Clear all text annotations in the Display.

Exit Cursors Clear all cursors, markers, and text.

3.4. Tutorial: Changing the Display Settings

Because there are so many different options and combinations for the Display element, the best way to learn how to customize the Display is by using it. These tutorials cover the basics of using and customizing the Display window to help get you started.

While you are exploring, remember that you can always try to double click on an object (a plot, cursor, marker, etc.) to change its settings. Changing the arrangement of the Display window or the plot types is always done using the Layout menu.

These tutorials build on the instrument you created in the previous chapter. Using the four input channels of the A/D Demo element, we will configure the plots currently in the Display window, along with creating new ones. The majority of activity in this section will take place in the Display Layout dialog, which is opened with the Display window's Layout menu command.

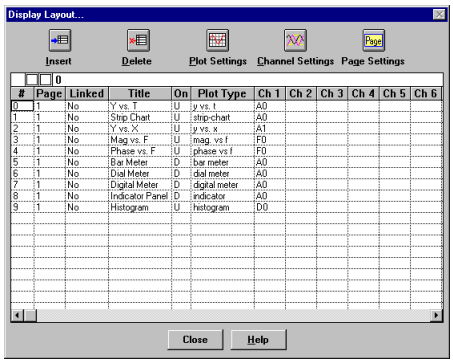

Display Layout...
Insert
Delete
Plot Settings
Channel Settings
Page Settings
0
Page Linked Title On Plot Type Ch 1 Ch 2 Ch 3 Ch 4 Ch 5 Ch 6
0 1 No Y vs. T U y vs. t A0
1 1 No Strip Chart U strip-chart A0
2 1 No Y vs. X U y vs. x A1
3 1 No Mag vs. F U mag. vs f F0
4 1 No Phase vs. F U phase vs f F0
5 1 No Bar Meter D bar meter A0
6 1 No Dial Meter D dial meter A0
7 1 No Digital Meter D digital meter A0
8 1 No Indicator Panel D indicator A0
9 1 No Histogram U histogram D0
Close
Help

Figure 3-25. Display Layout Dialog Box

Changing Line Colors and Styles

The first thing you may want to change is the color of the waveforms in the Display window. This will help differentiate the channels from each other, as well as contrast both the color of the grid and the background. The default colors for the Display window are configured by the Control Panel Color settings, but we can alter the color of different portions of the plot from the Plot Settings dialog box. To change the colors of the channels, we use the Channel Settings dialog box, shown in Figure 3-26.

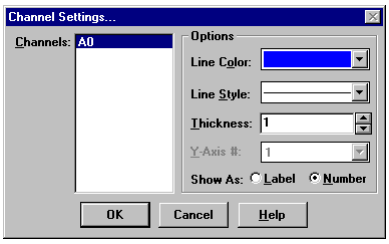


Figure 3-26 Channel Settings Dialog Box

There are a number of different ways to open the Channel Settings dialog box. This tutorial shows you the quickest way there. (For keyboard users, you must open the Display Layout table, move the selection box in the table to the desired plot, then open the Channel Settings dialog).

1. If the Display window for the instrument EXAMPLE1 is not open, double click on the Display icon in the instrument window.

Let’s change the color of the channel in the upper left corner Y-T plot.

2. Move the mouse pointer over the upper left plot labeled “A0 vs. Time” and click with the right mouse button. Select the Channel Settings item from the popup menu.

Another quick way to access the Channel Settings dialog is to hold down the CTRL key and double click on the plot. If you do not hold this key down when you double click, the Plot Settings dialog opens.

3. Select a new color for the waveform from the Line Color list. Notice that you can only have one color per waveform.

4. Press the OK button to accept the new color. If you do not want to accept the new color, press the Cancel button to retain the previous selection.

Before we start the instrument to see the effect of our changes, let's change the appearance of another channel. For those of you using a monochrome screen, the color selection might not make much difference, but the thickness will.

5. Open the Channel Settings dialog for the upper right plot labeled “A1 vs. Time.”

6. Change the line Thickness to 2.

The Thickness setting determines how wide the line is drawn. If you make the line too thick, the performance of the Display window decreases.

7. Press the OK button to accept the new settings.

8. Press the button.

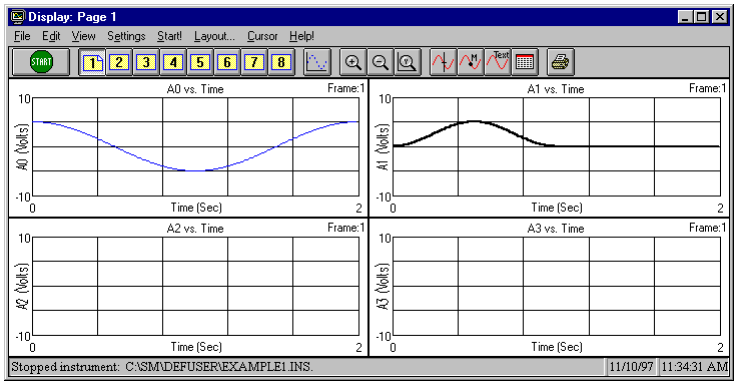


Figure 3-27. Multiple Color and Line Thickness

Deleting and Inserting Plots

By now, you may have noticed that not much happens in the plots of channels A2 and A3. One way to enlarge the plots for channels A0 and A1, we can delete the bottom two plots from the Display Layout table.

1. Select the Layout command in the Display window.

2. Highlight the third and fourth rows in the table by clicking and dragging from line 3 to line 4.

3. Press the Delete button .

   The Confirm message box appears asking if you want to delete the selected plots. This is a safety measure to ensure that you did not press the Delete button inadvertently.

4. Press the Yes button in the Confirm message box.

5. Press the Close button to close the Layout dialog.

   Notice that the plots of A0 and A1 have been enlarged to the maximum size within the Display window.

   Only channels A0 and A1 are now displayed. This brings up an important concept: not all channels of data need to be displayed when the instrument is running. There is, however, a tradeoff. The more channels Snap-Master must handle, the more horsepower needed to handle all of them. As a rule, you should use the fewest number of channels needed to complete your task.

   Simply being able to delete a plot is not of much use if you can not insert a new one when you are interested in viewing more data. In fact, you can even view the same data in two different plots!

Overplotting Multiple Channels

Using the overplotting feature of Snap-Master, you can display up to 16 different channels of data on the same set of axes. This is useful when comparing similar data sets.

1 Select the Layout command.

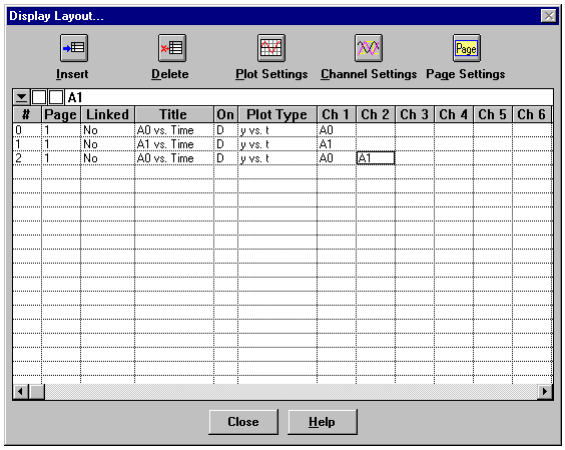

Display Layout...
Insert
Delete
Plot Settings
Channel Settings
Page Settings
A1
Page Linked Title On Plot Type Ch 1 Ch 2 Ch 3 Ch 4 Ch 5 Ch 6
0 1 No A0 vs. Time D y vs. t A0
1 1 No A1 vs. Time D y vs. t A1
2 1 No A0 vs. Time D y vs. t A0 A1
Close
Help

Figure 3-28 Overplotting Display Settings

2 Move the selection box to the third row, then press the Insert button .

A new plot appears as (Untitled 3). Notice that the default plot type is y vs. t and that no channels are assigned yet.

3. Move the selection box to the Ch1 column in the third row. Click on the pull-down arrow located in the upper left corner of the table, and double click A0.

This pull-down list is an important feature of all tables in Snap-Master. The contents of this list depend on the current position of the selection box. We will use the list often in these tutorials to give you an idea what options are available.

4. Move the selection box to the Ch2 column in the third row and select channel A1.

Use the pull down list to specify the channels as done in previous steps. These additional channel columns are the overplotted channels.

5. Press the Close button.

6. Press the button.

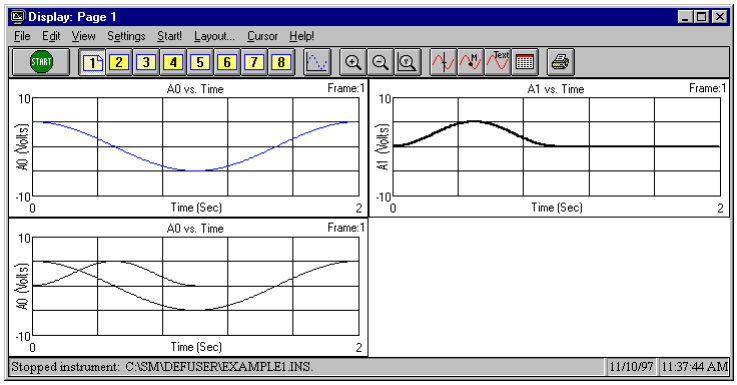


Figure 3-29 Overplotting Channels

The new set of axes contains the same information from the top two graphs plotted simultaneously. However, notice that the colors and line thickness are different from what you specified for the original two plots of A0 and A1. This is because the colors and line type settings apply only to a specific plot and not globally for all plots. Use the Channel Settings dialog box for the channels in the third plot to change the colors and line style.

Strip-Charts and Y-X Plots

Now that we have looked at some ways to change the Y-T plots, we can now look at the other plotting types in the Display element: Strip-Charts and Y-X plots.

1 Select the Layout command.

2. Position the selection box in the second row, Plot Type column.

3. Select the Strip Chart item from the pull-down list.

Here is another use for the pull-down list in the upper left corner of the Settings table. When you view the list this time, it contains the different plot types instead of the available channels. This is because the selection box is located in the Plot Type column and the list is context sensitive. We will review how to use this list box again.

4. Position the selection box in the third row, Plot Type column.

5. Change the plot type to Y vs. X.

For the third plot, we will try something a little different. The Y vs. X plot type plots the channels listed in the Display Settings table (the dependent variables) against the channel used as the basis for the X-axis, which is specified in the X-Axis Settings (the independent variable). Since we only need to look at one channel here, let's delete the first channel.

6. Position the selection box in the third row, Ch1 column. From the pull down list of channels, select "(None)".

When you delete a channel from the plot, the channels shift to the left to keep the row complete. In this case, channel A1 is now Ch1.

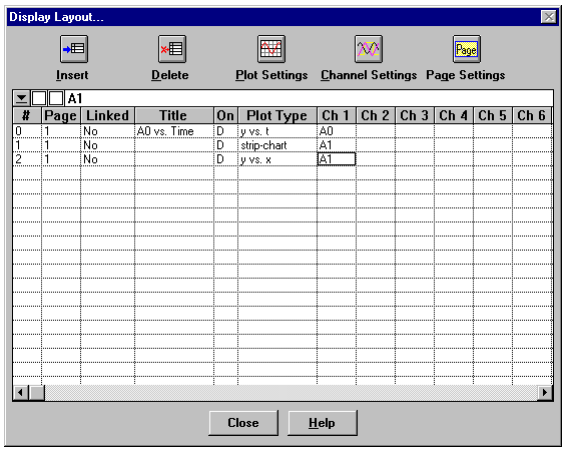

Display Layout...
Insert
Delete
Plot Settings
Channel Settings
Page Settings
A1
Page Linked Title On Plot Type Ch 1 Ch 2 Ch 3 Ch 4 Ch 5 Ch 6
0 1 No A0 vs. Time D y vs. t A0
1 1 No D strip-chart A1
2 1 No D y vs. x A1
Close
Help

Figure 3-30 Multiple Display Types

7. Press the Close button.

   Even though there is a plot of A0 vs. A1 for the Y-X plot, let's look at how the basis channel for the X-axis is set. To do this, we will use another mouse shortcut to open the X-Axis Settings.

8. Right click on the Y-X plot and select the X-Axis Settings menu command.

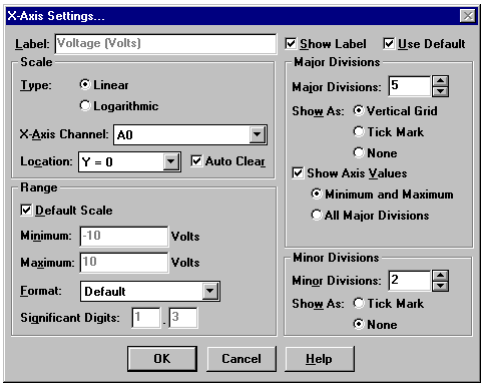


Figure 3-31 X-Axis Settings for Y vs. X Plot

9. Select channel A0 from the X-Axis Channel list.

   The Channel specifies the basis for the X-axis, or the independent variable. In this example, we want channel A0 to be the basis for the X-Axis.

10. Close the X-Axis settings by pressing the OK button.

11. Press the

button.

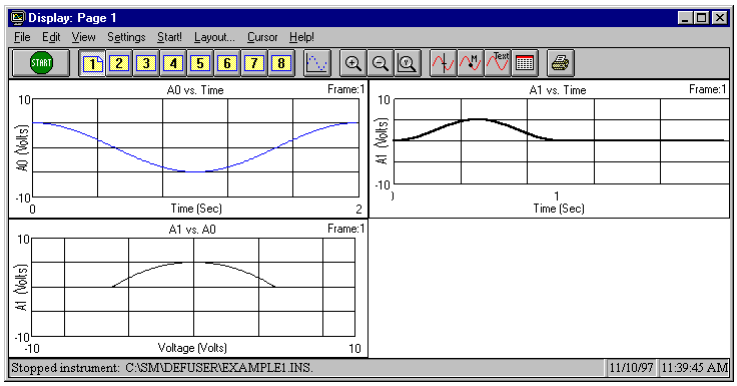


Figure 3-32 Displaying Multiple Plot Types

The Display window should now include all three plot types. Notice that the titles reflect the different plot types by indicating the dependent and independent variables for each set of axes.

Changing Other Plot Components

To further customize the appearance of the Display window, you may want to alter the title of the plot, manually set the range of displayed values, display a legend, change the grid lines and tick marks, and change the colors of the different plots. These settings are controlled with the Plot Settings, X-Axis Settings, and Y-Axis Settings dialog boxes. Remember that you can right click on the plot to select these dialog boxes, or double-click on the item you wish to change. We will change some of these settings to show you how to use the dialog boxes.

(For keyboard users, you must access these dialogs through the Display Layout dialog.)

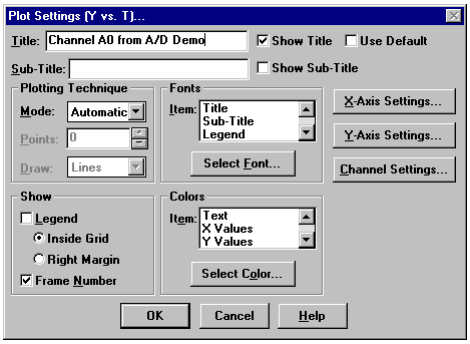


Figure 3-33 Y vs. T Plot Settings

1. Double click in the center of the Y-T plot located in the upper left corner of the Display window.

   This opens the Plot Settings dialog for the Y-T plot. Notice that we can access the X-Axis Settings, the Y-Axis Settings, and the Channel Settings from this dialog. This is the same dialog that appears when you select the Plot Settings button in the Display Layout dialog.

   Let's change the title of the plot using this dialog. Notice that we can also turn on the Legend and Frame Number in this dialog, as well as change the colors and fonts for the different plot components.

2. Turn off the Use Default check box to the right of the Title text box.

   This allows us to enter out own text for the plot.

3. In the Title field, type *Channel A0 From A/D Demo.*

4. Press the OK button.

   The title for the Y-T plot should now be changed to our new title. Now let's turn on all of the values on the X-Axis of the Y-X plot.

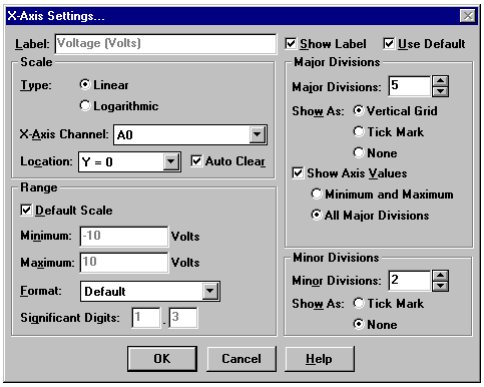


Figure 3-34 X-Axis Settings With All Values Shown

5. Double click on the X-Axis region of the Y-X plot located in the lower left corner of the Display window.

6. Select the All Major Divisions radio button under the Show Axis Values check box.

   The axis values are now shown at each major division.

7. Press the OK button.

   You should now see a value underneath each grid line on the X-Axis. As you can see, there are a number of options available for customizing the Display window. Experiment with each setting to determine the best way to present your data.

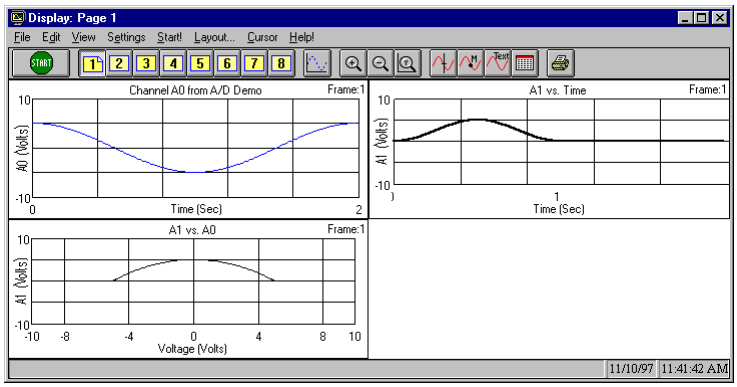


Figure 3-35 User Defined Title and Axis Values

3.5. Tutorial: Using Display Pages

Now that we have customized the individual plots, how do we customize the Display layout even further? For example, how do we make the Y-X plot full screen? Also, how do we rearrange the Y-T and Strip Chart plots to appear in two rows instead of one?.

Moving a Plot To A New Display Page

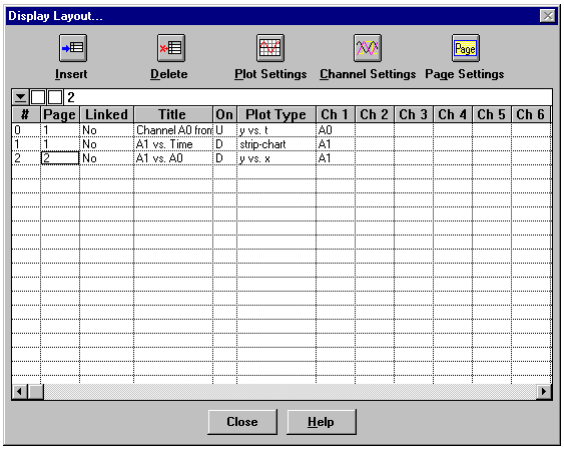

Display Layout...
Insert
Delete
Plot Settings
Channel Settings
Page Settings
2
Page Linked Title On Plot Type Ch 1 Ch 2 Ch 3 Ch 4 Ch 5 Ch 6
0 1 No Channel A0 from U y vs. t A0
1 1 No A1 vs. Time D strip-chart A1
2 2 No A1 vs. A0 D y vs. x A1
Close
Help

Figure 3-36 Display Layout Using Multiple Pages

1 Select the Layout menu command.

2. Position the selection box in the third row, Page column.

3. Change the page to 2.

Again, we use the drop down list to select a Display page. There are 8 possible pages to choose from, and an “N” option. The “N” page is a null page where a plot is moved if you do not want to delete it (in case you have customized many of the settings) and you do not want to plot it.

Changing The Display Page Title

Each Display Page can have its own title, which is shown in the title bar of the window. Let’s change the title for Page 2.

1. Press the Page Settings button

.

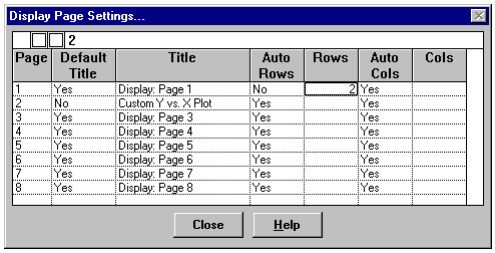

Display Page Settings...
2
Page Default Title Title Auto Rows Rows Auto Cols Cols
1 Yes Display: Page 1 No 2 Yes
2 No Custom Y vs. X Plot Yes Yes
3 Yes Display: Page 3 Yes Yes
4 Yes Display: Page 4 Yes Yes
5 Yes Display: Page 5 Yes Yes
6 Yes Display: Page 6 Yes Yes
7 Yes Display: Page 7 Yes Yes
8 Yes Display: Page 8 Yes Yes
Close
Help

Figure 3-37 Display Page Settings

2. Position the selection box in the second row, Title column.

3. Type *Custom Y vs. X Plot*, then press ENTER.

Notice that when you press ENTER with your new title, the Default Title column changes to No. This means that you are using your custom title. (To change back to the default title for the page, move to the Default Title column and select Yes from the list.)

Changing The Display Page Rows and Columns

Another item in the Display Page Settings dialog is the number of rows and columns for the page. This is where we can change how the plots are arranged in the Display window.

1. Position the selection box in the first row, Rows column.

Right now, Page 1 has two plots in it. By default, Snap-Master arranges these side by side in one row (or two columns). If we want each plot to take up the full width of the Display window, we can override the default by entering a new number of rows.

NOTE: If you change these settings and add plots to the page at a later time, the plots may not appear where you expect them to. Make sure the Page Settings match the number of plots configured for the page.

2. Enter *2* for the number of Rows.

With this setting, Page 1 will always have two rows when laying out the plots. Because we only have two plots, each will be placed in its own row.

3. Press the Close button to close the Display Page Settings.

4. Press the Close button to close the Display Layout dialog box.

Running the Instrument

1. Press the

button.

When you run the instrument , notice that Page 1 uses the full width for both plots. If you switch between pages while the instrument is running using the

and

buttons, only the new data is plotted - the full displays do not appear until a new frame begins.

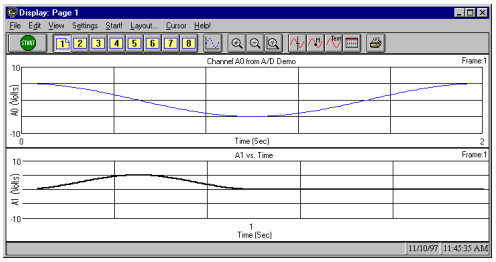


Figure 3-38 Display Page 1 With Two Rows

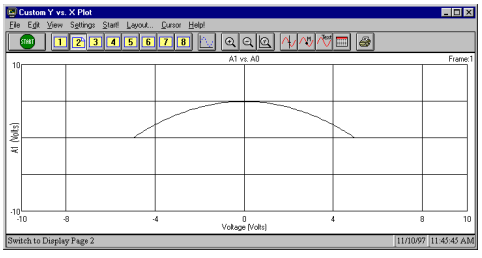


Figure 3-39 Display Page 2 With Custom Title

3.6. Tutorial: Using Cursors And Markers

Cursors and markers are a quick way to get quantitative data from the Display window, as well as mark specific points of interest. In this section, we will place a cursor to read the data values from the plot, and we will also find the slope between two points. Placing a markers uses the same method as placing a cursor.

Placing A Cursor

1. Change the Display Page back to Page 1 .

   For simplicity, we will place the cursor on the Y-T plot of channel A0. Assuming you have followed the tutorials to this point, this is the upper plot on Display Page 1.

2. Press the button, or select the Cursor menu, New Cursor command.

   After you press the button, the Cursor Data table appears. By default, the table appears in the Display window itself. If you want it in its own window, right click over the table and select the Toggle Location menu command.

3. Move the mouse pointer over the upper plot, and press the right mouse button.

   When you move the mouse pointer over a plot, the mouse pointer changes to .

   When you click on the mouse button, a cursor is placed at the corresponding X-axis location on the channel, and the mouse pointer returns to the standard pointer. You do not have to be directly on top of the waveform to place a cursor. A new entry appears in the Cursor Data table for the cursor you placed.

   If you are having trouble placing the cursor try retracing the data with the button, then place the cursor.

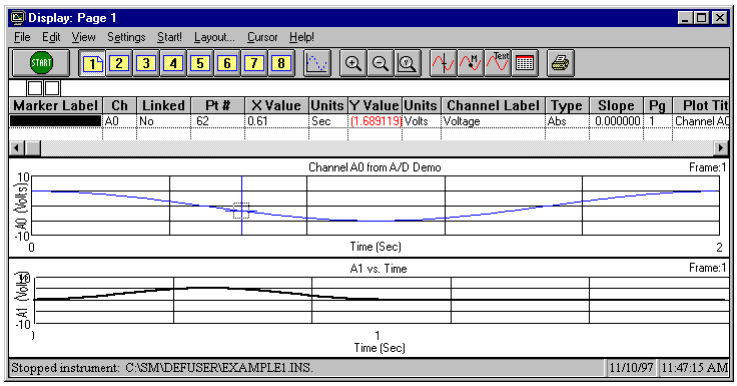


Figure 3-40 Display With Cursor In Upper Plot

Moving The Cursor

Once the cursor is placed, you will usually want to move it to the location where you want to read the data value. There are two ways to move the cursor.

1. With the mouse pointer located over the upper plot, press the right and left mouse buttons to move the cursor forward (right mouse button) and backward (left mouse button) in time.

    When you press the mouse buttons, the Skip Rate value is used to determine how many points to move. By default, the Skip Rate is 1.

2. Move the mouse pointer over the cursor's hot spot (the dotted rectangular box where the cursor and data meet). Press and hold the right mouse button, then move the mouse to the right and left to drag it.

    Here is another method of moving the cursor that works better for large distance moves. Notice that with each move the Cursor Data window updates to the value at the current position.

Finding The Slope Between Two Points

Instead of using two cursors and calculations to find the differences between two points, let's use a Relative Cursor.

1. Double click on the cursor's hot spot to open the Cursor Setup dialog.

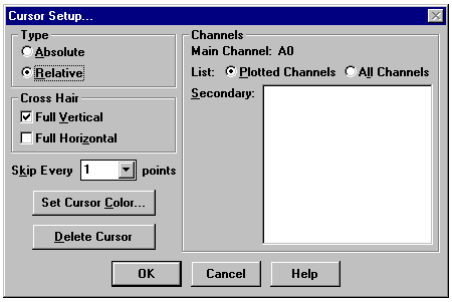


Figure 3-41 Relative Cursor Setup

2. Change the cursor type to Relative.

    The default mode for a new cursor is Absolute which displays one point at a time. The Relative mode displays the differences and slope between two points in the Cursor Data table.

3. Press OK to close the Cursor Setup.

    When you return to the Display window, the cursor now has two solid circles at the top and bottom of the plot which are called "anchors". The anchor defines the starting point for all difference calculations.

4. Click on the cursor's hot spot and drag the cursor to the right.

    When you drag the cursor, a new cursor appears, the anchored cursor remains in place, and a line is drawn connecting the two cursors to represent the slope between the points. Notice that the values in the Cursor Data table are showing the difference between the points and the Slope column is calculated automatically. You can also click on the anchored cursor and move it independently of the relative cursor.

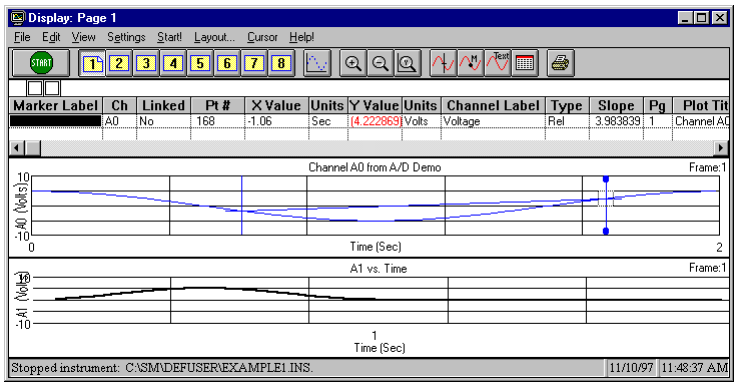


Figure 3-42 Display With Relative Cursor

Using Linked Cursors

Now that we have a cursor on the upper plot, let's add a cursor to the lower plot and link them together so they move in tandem.

1. Press the button, or select the Cursor menu, New Cursor command.

2. Move the mouse pointer over the lower plot, and press the right mouse button.

   A cursor now appears on the strip chart of channel A1. You should see two entries in the Cursor Data table now - one for A0 and one for A1.

3. In the Cursor Data table, highlight the first two rows in the Linked column and select 1 from the pull down menu.

   This assigns these cursors to link group 1. Any number of cursors and markers can belong to a link group.

4. Move the cursor in the upper plot. Notice that the cursor in the lower plot immediately moves to the same X-axis location and tracks along with the movement of the cursor you are moving.

5. Move the cursor in the lower plot. Notice that the cursor in the upper plot also tracks with any changes in the linked cursor.

Chapter 4. Disk I/O

4.1. Data File Overview 4-1
4.2. Disk In 4-4
4.3. Disk Out 4-8
4.4. Tutorial: Saving Data To Disk 4-12
4.5. Tutorial: Reading Data From Disk 4-14
4.6. Data File Formats 4-15

4.1. Data File Overview

Snap-Master reads both binary and exponential (also called ASCII or text) data files in a number of formats. There are three native file formats: Standard Binary, Fast Binary (also called FBDF for short), and Exponential. In addition, Snap-Master can import and export data in a number of generic formats, including Plotter and Comma Separated Variable (or CSV) files. Each format has its own advantages, and there are some general rules to follow when selecting the proper format for your instrument.

The difference between the native Snap-Master data file formats and the generic file formats is how the file is organized. Snap-Master native files use a format which contains a header and separate data frames. The header provides information on the data file that is used by the Disk In element to accurately recreate the data for post-processing. Generic data files do not contain this header, and the data is presented as one large series without any frame divisions.

Text-based data files (including the Exponential, ASCII Plotter, and CSV formats) files store the data as a standard ASCII text file that can be read by most programs. Also, the file can be read by humans using the DOS TYPE command. The main advantage of this universal data type is that the file can be read by most programs, including word processors, spreadsheets and databases.

There are two disadvantages when using an ASCII file format: the files require a large amount of disk space (up to eight times more than a binary file), and the files take proportionally longer to write to disk (up to ten times longer). Therefore, ASCII files should be used when the data is acquired at low speeds, or when the data must be exported to an external program.

The most efficient method of storing data is by writing the file in one of Snap-Master's binary formats. The binary files have a faster read and write time, but they may not be able to be read by external programs. In general, binary files are used for large data files or for higher acquisition rates.

Native Data Files

Format		Data Type	Frame Based?	Display While Storing?	Speed	Frequency Data?
Standard Binary	.DAT	Binary	Yes	Yes	Med	Yes
Fast Binary (FBDF)	.DAT	Binary	Yes	No	High	No
Exponential	.DAT	ASCII	Yes	Yes	Low	Yes

In Snap-Master, there are two native binary data file formats: Standard Binary and Fast Binary. Standard Binary files are sufficient for applications where the aggregate sampling rate is less than 10 KHz, or when performing post-process analysis on previously acquired data. (To find the aggregate sampling rate, multiply the number of channels by the sampling rate per channel for each input element. If you have more than one source of data, then add these values together.) The main advantage of this format is the data is converted to floating point numbers (using engineering units, if defined by the Sensor) for use by all of the Snap-Master elements, including the Display which allows you to view the data while saving it to disk.

The Fast Binary data format is optimized for high speed data acquisition. The main difference between it and the Standard Binary files is the Fast Binary does not convert the acquired data into the floating point number before it is written to disk. This saves time during the write cycle and allows for a higher throughput rate. In addition, all of the input channels are written to the disk file in order to maximize the performance.

While the instrument is writing data using the Fast Binary format, data can not be viewed using the Display element. This is because displaying data on the screen requires numerous calculations, which in turn reduces the speed of writing the data directly to disk. Therefore, if you attempt to start an instrument with an element that does not support the Fast Binary data format, a message will appear on screen informing you that the instrument can not run in its current configuration.

NOTE: If you are using the Fast Binary data format, DO NOT use any disk caching software (such as SMARTDRV, which comes with Windows). Disk caching software will degrade the performance of the Fast Binary format and your actual throughput rates will be lower than without the cache.

Generic Data Files

In addition to the native file formats, Snap-Master can also read and write data in generic formats that can be used by other programs. These formats include:

Format		Data Type	Frame Based?	Display While Storing?	Speed	Frequency Data?
Binary Plotter	.PLT	Binary	No	Yes	Med	Yes
ASCII Plotter	.PLT	ASCII	No	Yes	Low	Yes
Comma Separated Variable	.CSV	ASCII	No	Yes	Low	Yes

Data File Naming Conventions

When creating a Snap-Master native data file using a .DAT extension, you are actually writing data to more than one file. Each .DAT file acts as a reference to a number of .SM? files with the same file prefix. The .SM? files contain the actual data from the elements, where the ? is replaced by the element letter.

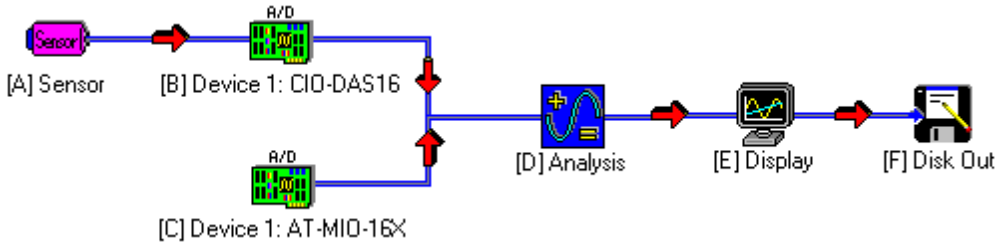


Figure 4-1 Sample Data File Naming Instrument

For example, this instrument is writing data in Standard Binary format to a file named TESTDATA. The first file that is created is TESTDATA.DAT. In addition, for each element you are saving data from (such as the B and C elements), the files TESTDATA.SMB and TESTDATA.SMC are created. TESTDATA.SMB will contain the raw data from the A/D Board marked element B, and the raw data from element C is saved in TESTDATA.SMC. If the Analysis element is creating new data channels such as R0, then a TESTDATA.SMR file is created.

The generic file formats use the extension assigned by the format when writing the data file (such as .PLT or .CSV). In addition, data from only one element letter can be stored in a generic file. This is because it is possible for each element letter to have a different number of points to save, so Snap-Master imposes this restriction when creating data files with the Disk Out element.

4.2. Disk In

The Disk In element read data from a previously stored file into the instrument. These data files are usually in one of Snap-Master's native file formats (Standard Binary, Fast Binary, or Exponential). Disk In also imports data files from Snap-Series, as well as various generic ASCII file formats.

Disk In Settings

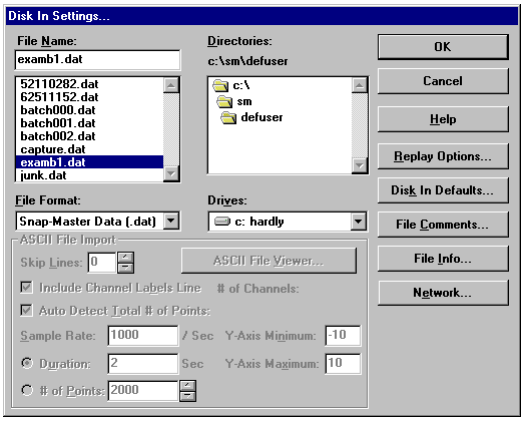


Figure 4-2 Disk In Settings

The Disk In Settings dialog box specifies the data file being replayed and its format. The upper half of this dialog operates like the standard Windows File Open dialog boxes. The File Name field specifies the data file to be replayed from the specified Directory (the default directory is SM\DEFUSER). To specify the type of file, select the appropriate choice from the File Formats list. When you select a File Format, the extension is automatically placed in the File Name field and the current directory is scanned for files with that extension.

When you replay a data file with the Disk In element, the element letters it produces depends on the format of the file. For the native Snap-Master formats (Standard Binary, Fast Binary, and Exponential), the element letters are the same as when the file was created. For example, if the data from channels A0, A1, and R0 was written to disk, then they remain A0, A1, and R0 when replayed. If there is an element letter conflict with any other element in the instrument, Snap-Master re-letters the elements to use an unused letter. For files that are imported into Snap-Master (including Snap-Series and generic file formats), the output channels use the same element letter as the Disk In element.

ASCII File Import

When you specify an ASCII data file (such as a Comma Separated Variable or ASCII Plotter), the ASCII File Import Group is activated. These settings determine how Snap-Master imports the data from the file in order to make the data compatible with the other Snap-Master elements in the instrument.

Skip Lines	Specifies the number of lines at the beginning of the file to ignore. Useful if the ASCII file contains a header.
ASCII File Viewer	Displays the first 4096 bytes of the ASCII file.
Include Channel Labels Line	If the file contains the names of the channels in the line immediately before the data, turning on this check box to automatically assign the channel names in the instrument.
Auto Detect Total # of Points	When selected, the Disk In element counts the number of CRLF (Carriage Return Line Feeds) to estimate the number of data points in the file. Use this value to set up the points per frame by dividing the total number of points in the data file by the number of frames you wish to subdivide the data into.
Sample Rate	Defines the sample rate for the data. Required to set the frame characteristics.
Duration	Defines the time duration for each frame of data. Required to set the frame characteristics.
# of Points	Defines the number of points per frame of data. Defines the duration for each frame of data. Required to set the frame characteristics.
Y-Axis Minimum	Specifes the default minimum value used by the Display element when configuring a plot.
Y-Axis Maximum	Specifes the default maximum value used by the Display element when configuring a plot.

Replay Options

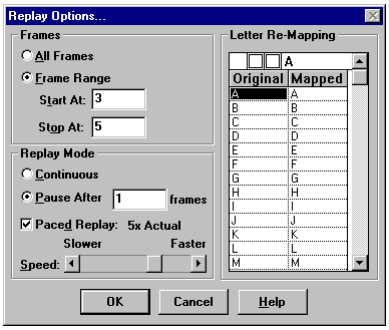


Figure 4-3 Disk In Replay Options

The Replay Options button is only available when replaying native Snap-Master data files. Using the different selections, you can control how the file is replayed in the instrument.

Frames

All Frames — Replays all of the frames in the data file.

Frame Range — Replays only the frames between the **Start At** and **Stop At** frames (inclusive).

Replay Mode — Specifies how the selected frames are replayed. **Continuous** replays the entire selection without stopping between frames, while **Pause After** specifies how many frames are replayed before stopping the instrument. Restarting the instrument continues from the next frame until the Frame Range is exhausted, in which case Disk In starts over from the starting frame.

For example, the settings in Figure 4-3 are set to replay from frame 3 to frame 5 and pause after each frame. The first time you run the instrument frame 3 replays, then the instrument stops. When you start the instrument again frame 4 replays, then the instrument stops. Another start replays frame 5, then the instrument stops. If you restart the instrument after it has replayed all of the frames defined in the Replay Options dialog box, then the Disk In element returns to the beginning of the frames defined, in this case frame 3.

Paced Replay — When selected, the data file replays at the original acquisition speed of the file. This means that a five second frame in the data file takes five seconds to replay. The **Speed** scroll bar adjusts the replay rate to faster or slower using the scroll bar. Paced Replay works best with Standard Binary files acquired at slower rates (under 1000 Hz aggregate). If you attempt to replay a file too quickly you could receive an "overrun" error from the Disk In element, so slow down the replay rate. The actual performance is dependent on your computer system and the complexity of the Snap-Master instrument.

Letter Re-mapping

The Letter Re-mapping feature allows you to "change" the element letters of the incoming data files. This is accomplished by assigning an Original element letter to a Mapped letter. This can be useful when trying to replay multiple data files that have the same source element letters, such as two data sets containing .SMA files.

For example, the dialog box shown in Figure 4-3 changes data with the element letter A to use element letter M. For example, assume the data saved in this file came from the element letter A. Using the Letter Re-mapping feature of Disk In, channel A0 appears as channel M0 in this instrument. This is useful when trying to replay multiple data files that have the same source element letters such as when the A/D element is consistently element letter B in all of the instruments used to acquire and store the data.

Default Settings

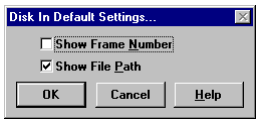


Figure 4-4 Disk In Default Settings

Show Frame Number	Displays the current frame number in the instrument window in the caption of the element.
Show File Path	Displays the complete file path in the instrument window in the caption of the element.

File Comments

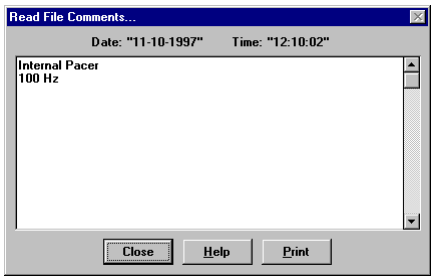


Figure 4-5 Read File Comments

The File Comments button allows the user to read the file comments stored in the data. The File Comments can only be read from native Snap-Master file formats, and are not editable from this dialog box. The Print button sends the information from the Comments section of the header to the default printer.

File Information

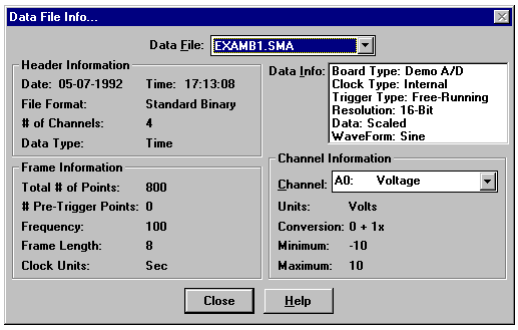


Figure 4-6 Data File Info

The File Info button shows detailed information about the data file from the file header. This command is only be available when a native Snap-Master data file is selected.

The Data File lists the .SM? files associated with the .DAT file specified in the File Name. The Header Information, Frame Information, and Data Info shows the parameters that apply to the entire data file. The Channel Information shows the available channels along with any channel specific information.

4.3. Disk Out

The Disk Out element writes data from the instrument to a disk file. You can use any disk drive supported by Windows to store your data, including hard disks and RAM disks. Disk Out writes files in Snap-Master native formats, as well as exports data to ASCII files

Disk Out Settings

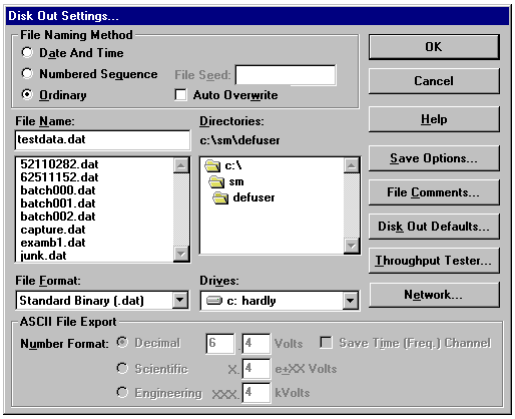


Figure 4-7 Disk Out Settings

The Disk Out Settings dialog box specifies the name of the data file and the format it is written to. A number of file naming methods are available, as well as the native and generic Snap-Master data file formats.

The middle of this dialog operates like the standard Windows File Open dialog boxes. The File Name field specifies the data file to be replayed from the specified Directory (the default directory is SM\DEFUSER). To specify the type of file, select the appropriate choice from the File Formats list. When you select a File Format, the extension is automatically placed in the File Name field and the current directory is scanned for files with that extension.

File Naming Method

Date and Time — Creates a data file based on the date and time when the instrument is started. using the current month, day, hour, minute, and fraction of minute to name the file.

The month is indicated by a single number for the months January (1) through September (9), with October (O), November (N), and December (D) using the first letter in the month name. The day, year, and minute use two digits each (including any necessary leading zeroes). For the fraction, the minute is divided into 10 equal sections of six seconds each.

For example, if you start the instrument at 11:32:30 AM on October 27, the data file will be named O2711305.DAT.

Numbered Sequence	Creates a data file series by appending the File Seed with a sequence of numbers to create an eight character file name. For example, assume the File Seed is TEST. The first time the instrument is run, the first file created is called TEST0000.DAT. The next time the instrument is run, the new data file is called TEST0001.DAT. The next time, the file is called TEST0002.DAT, after that TEST0003.DAT, and so on. This allows the user to run the same test multiple times without creating a new file name for each run.
Ordinary	Creates a data file using the File Name. If the instrument is run and the file name specified in the File Name field already exists, then Snap-Master asks you if you want to overwrite the file or change the file name using the File Exists dialog box. To inhibit the File Exists dialog, turn on the **Auto Overwrite** check box to always overwrite an existing data file.

ASCII File Export

When you select an ASCII File Format (such as a Comma Separated Variable or ASCII Plotter), the ASCII File Export Group is activated. These settings determine how Snap-Master writes the data from the file.

Number Format	Specifies the text format of the data in the file. The **Decimal** format specifies an absolute number of digits for the numbers before and after the decimal, and results in consistent columns for each data point. Using the **Scientific** format produces numbers that always show the value in terms of an exponent of 10. **Engineering** units allows the user to set the precision of the data file by specifying the number of places after the decimal.
Save Time (Freq) Channel	When selected, the first channel of the data file contains the elapsed time from the instrument start of each data point. If the check box is not turned on, then there is no time or frequency channel included.

Save Options

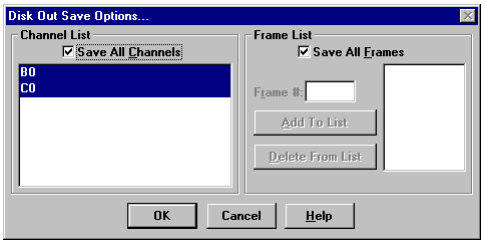


Figure 4-8 Disk Out Save Options

The Disk Out Save Options dialog specifies which channels and which frames to save to disk while the instrument is running. These options are useful for reducing the amount of data actually written to disk.

Channel List

Specifies which channels to write to the data file. If you are using the Fast Binary data file format, you must save all channels from any element letter you are saving. For the ASCII file formats, you can only save data from one element letter.

To save all of the channels, turn on the All Channels check box. If you want to select channels that are not continuously listed, turn off the All Channels check box, then press the CTRL key while selecting the channels with the mouse button.

Frame List

Specifies which data frames to save. To save all frames in the instrument, turn on the Save All Frames check box. If you want to specify a list of frames to save, turn off the Save All Frames check box, enter a number in the Frame # edit control, then press the Add To List button. You can add as many frame numbers to the list as you would like. To delete a frame, select one from the list box and press the Delete From List button.

Write File Comments

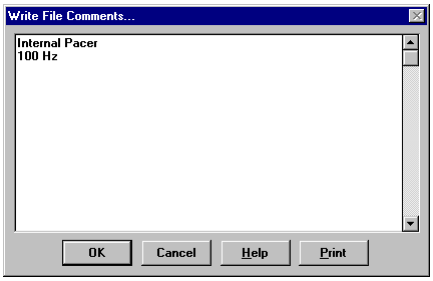


Figure 4-9 File Comments Dialog Box

By pressing the File Comments button in the Disk Out Settings dialog box, you can enter notes about the data files. Useful information that might be included in this field are special conditions in which the test was conducted, who conducted the test, etc. To create a new line of text in the field, press CTRL + ENTER. The Print button sends the information from the Comments section of the header to the default printer.

Disk Out Defaults

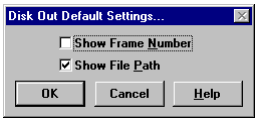


Figure 4-10 Disk Out Defaults

Show Frame Number	Displays the current frame number in the instrument window in the caption of the element.
Show File Path	Displays the complete file path in the instrument window in the caption of the element.

Throughput Tester

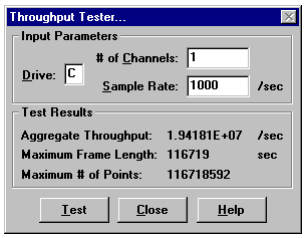


Figure 4-11 Throughput Tester

The Throughput Tester allows you to see how your hard disk will perform for high speed data acquisition and how much disk space you have available. For high speed acquisition, you must use the Fast Binary format to achieve maximum performance.

To use the Throughput Tester, enter the drive letter you want to write to (which is any letter from A to Z, and can be either a hard drive, floppy drive, RAM disk, or network drive), the # of channels you plan to write, and the sample rate per channel.

After the parameters are specified, press the Test button. Typically, the test takes between 5-20 seconds (depending on the parameters), during which time your hard disk light will turn on. The values given by the test should not be viewed as absolute performance characteristics. Rather, they should be used to gauge performance of your hard disk with Snap-Master.

NOTE: Disk caching software (such as SMARTDRV, which comes with Windows) will affect the actual performance of the hard disk. Be sure to disable any cache software before using the Fast Binary data format.

Overwriting Data Files

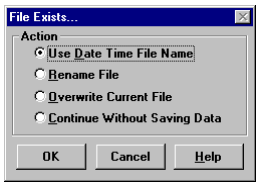


Figure 4-12 File Exists Dialog Box

If you start an instrument containing the Disk Out element and the file name already exists, Snap-Master will alert you with a dialog box before starting the instrument. To inhibit this dialog and always overwrite the existing file, select the Auto Overwrite check box in the Disk Out Settings dialog box.

Use Date Time File Name	Saves the current data to a file using the current date and time as the file name
Rename File	Opens the Disk Out Settings dialog to change the file name. When you press the OK button to close the Disk Out Settings, the instrument will start.
Overwrite Current File	Deletes the existing file and writes the new data to that file name.
Continue Without Saving	Disables the Disk Out element for this run of the instrument so no data is written.

4.4. Tutorial: Saving Data To Disk

Building the Instrument

Figure 4-13 Instrument for Disk Out Tutorial

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place the A/D Demo, Display, and Disk Out elements in the instrument.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the A/D Demo element to the Display element, and the Display element to the Disk Out element.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as DISKOUT.

Specifying The Data File Name

1. Open the A/D Demo Settings by double clicking on the element.

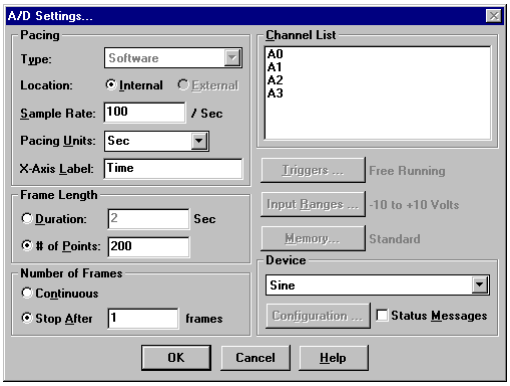


Figure 4-14 A/D Demo Settings

2. Change the Number of Frames to Stop After 1 frame.

3. Press the OK button to close the A/D Demo Settings.

4. Open the Disk Out dialog box by double clicking on the element.

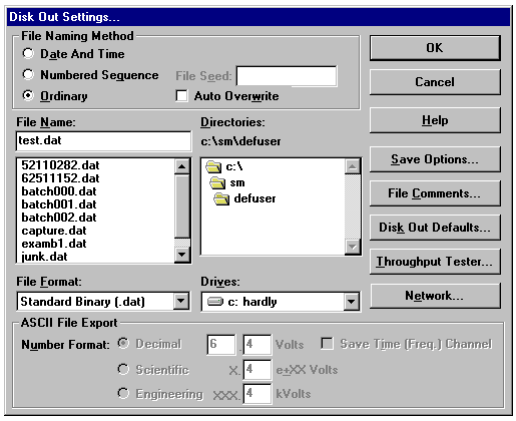


Figure 4-15 Disk Out Settings Dialog Box

5. Select the Ordinary File Naming Method.

   Notice that when you select the Ordinary method, the File Name edit control is activated.

6. Enter the file name *TEST* in the File Name edit control.

   You only need to do type the file name in the File Name field because Snap-Master automatically adds the .DAT extension. The default directory for data files is the DEFUSER subdirectory of the SM directory.

7. Click the OK button in the Disk Out dialog box.

8. Save the instrument with the button or with the File menu, Save command.

Running The Instrument

When you run the instrument, you will see the data in the Display window while it is being saved. Because the primary task of Snap-Master is to accurately write the data to disk, the Display may not plot continuously. If you are interested in speeding up the performance of the plotting, try using the different Plotting Techniques.

If you run the instrument a second time, the File Exists dialog box appears. This is because the file C:\SM\DEFUSER\TEST.DAT already exists, so Snap-Master is making sure you do not want to overwrite the file. To inhibit the File Exists dialog, select the Auto Overwrite check box in the Disk Out Settings dialog box.

4.5. Tutorial: Reading Data From Disk

Building the Instrument

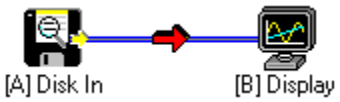


Figure 4-16 Instrument for Disk In Tutorial

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place the Disk In and Display elements in the instrument.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the Disk In element to the Display element.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as DISKIN.

Specifying The Data File Name

1. Open the Disk In Settings by double clicking on the element.

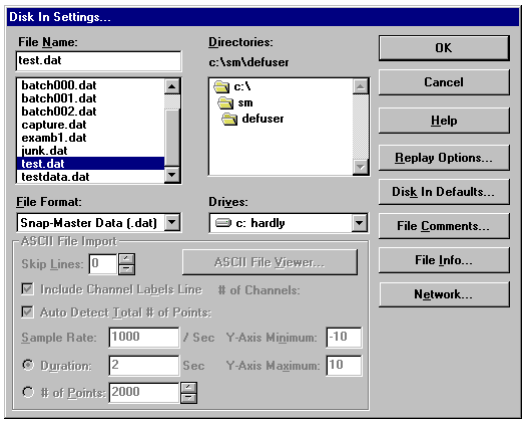


Figure 4-17 Disk In Settings

2. Select the data file TEST.DAT by clicking on it in the File list.

3. Press the OK button in the Disk In dialog box.

4. Save the instrument with the button or with the File menu, Save command.

Running The Instrument

When you start the instrument, the Display window opens and displays the data stored in TEST.DAT. The data should look the same as it did in the previous tutorial where you saved the data to disk. Notice that you can zoom in and out or use cursors and markers as if the data were just acquired.

4.6. Data File Formats

This section of the manual documents the actual file formats used by Snap-Master's native file formats, as well as some of the generic file formats. This information will only be useful to users who plan on creating their own programs to write or read Snap-Master data files (such as custom file format converters or custom analysis programs).

Data File Structure

Whenever data is saved in one of Snap-Master's standard file format, at least two files are created: a .DAT file and one .SM* file for every element saving data. The actual data (including headers) is stored in the .SM* files, and the .DAT file acts as a pointer to all .SM* files with the same file prefix. The last letter in the file extension must correspond with the element letter in the CHAN$ array for proper operation.

All .SM* files consist of two major sections: the file header, and the data frames. The file header defines the parameters used in the data file, and the values for these parameters.

Each frame of data consists of two parts: the frame header and the raw data. The beginning of a new frame header is specified by a "TR", followed by the frame number. The next line contains a date and time stamp for the start of the frame.

Section	**Contains**
File Header	Introduction Parameter Name and Value List
Data Frame	Frame Header Data
Data Frame	Frame Header Data
Data Frame	Frame Header Data

etc. for the remaining frames.

Some important items to note when writing a Snap-Master data file:

- Spaces are ignored when reading the data file, except after an equal sign (=) that defines a numerical value where there must be no spaces.
- Snap-Master only understands its own internally declared parameters.

Header Information

The file header contains information used by Snap-Master to determine the parameters applicable to all data frames contained in the file. If the data file does not correspond to the settings in the header, then the file will not be replayed correctly.

The file header for a Snap-Master data file consists of two parts: the introduction, and the parameter list. The introduction contains an initialization line and the user-defined comments for the data file. The parameter list gives the parameter variables used in the data file, and the values for each parameter.

Initialization Line	The first line in the file header starts with "Snap-Master Data File", a comma, and a number specifying the number of parameters appearing in the data file, including the Comments line.
Comments	The next line(s) contains the user defined comments which are entered in the File Comments field of the Disk Out dialog box. Comments are preceded by "COMMENT$", a comma, the number of characters in the string, a comma and an equal sign, and the text string enclosed in quotation marks.

The format for the available parameters for Snap-Master data files are listed in the following table. All values of *x* specify the character length of the value or string to the right of the equal sign.

"DATE$", 12, =	String that specifies the date that the file was created. The value is enclosed in quotes and follows the *"mm-dd-yyyy"* format.
"TIME$", 10, =	String that specifies the time that the data file was created. The value is enclosed in quotes and follows the *"hh:mm:ss"* format.
"ACT.FREQ", *x*, =	Numeric value of the sampling frequency per channel.
"ACT.SWEEP", *x*, =	Numeric value of the actual Frame Length used by Snap-Master.
"NCHAN%", *x*, =	Numeric value of the number of channels of data in the data file.
"CHAN$[]", *x*, =	List of strings specifying the element letter and channels in the data file. Entries are separated by a comma. All element letters must be the same and must correspond to the last letter in the .SM* file extension.
"NUM.POINTS", *x*, =	Numeric value of the number of points sampled per channel for each frame of data.
"CLOCK.UNITS$", *x*, =	String specifying the units used for the x-axis variable. For time-domain data, the value is the units used (such as Sec). For frequency data, the value is given as Hz.
"FILE.TYPE$", *x*, =	String specifying the file type. The settings for the different formats are as follows:
Exponential	x=30, Interleaved Analog Exponential
Standard Binary	x=25, Interleaved Analog Binary
Fast Binary	x=29, Interleaved Analog Binary Raw
"INTERLEAVE.FACTOR%", *x*, =	Numeric value representing the interleave factor of the data points, which is equal to the number of acquired channels.
"CONVERSION.POLY$[]", *x*, =	List of strings specifying the conversion polynomial for each channel in the CHAN[] array. In the Exponential file format, the data has already been converted using these equations. Each value is separated by a comma.

"UNITS$[]", *x*, =	List of strings specifying the engineering units for each channel in the CHAN[] array as specified by the Sensor element. Each value is separated by a comma.
"DEFAULT.LABEL%[]", *x*, =	List of integers which specifies the channel label. A 1 means the label from CHAN$ is used, and a 0 means the user defined label in CHANNEL.LABEL$ is used. Each value is separated by a comma.
"CHANNEL.LABEL$[]", *x*, =	List of strings of the user defined labels for each channel in the CHAN[] array. Each value is separated by a comma.
"CHANNEL.TYPES$[]", *x*, =	List of strings specifying the type of channel for each channel in the CHAN[] array. Each value is separated by a comma. For time data, the channel type is *yt*. For frequency data, the channel type is *yfp* (p is for polar frequency format data).
"CHANNEL.RANGES[]", *x*, =	Numerical range of values specifying the upper and lower limits of the data for each channel in the CHAN[] array. The values are usually determined by either the Sensor element or the Input Range of an input element. The range is enclosed in parentheses and separated by a comma (for example (-10,10)). Each channel is also separated by a comma.
"FFT.BLOCKSIZE%", *x*, =	Integer specifying the interleave size for amplitude and phase data. If no frequency data is in the file, this value is 2048. If frequency data is in the file and the value is 1, then the magnitude value is followed immediately by the phase value.
"CLUSTER.SIZE%", *x*, =	Used only with FBDF files. Integer specifying the cluster size of the disk that the file was written to.
"PRE.TRIGGER.PTS%", *x*, =	Specifies the number of points in each frame before the actual trigger event. Used for plots to place time “0” of the frame at the trigger event.
"DATAINFO$[]", *x*, =	List of strings that provides the user information about how the data was acquired.

Exponential Data File Format

Exponential data files are saved as text files, which can be read by other programs and by people using the TYPE command or a word processor. While these files are the easiest to write, they also require the most disk space of the file formats and require more time to replay into Snap-Master.

If frequency data is contained in the file, the FFT.BLOCKSIZE% parameter is always 1 for Exponential data files. This means that the magnitude part is always followed by the phase part for each data point. The data is written as interleaved floating-point numbers.

After the header, the Frame Header is written with a "TR" (which indicates a new frame), the frame number, a carriage return, the date the frame was started (in *mm-dd-yyyy* format, enclosed in quotation marks), the time the frame was started (in 24-hour format of *hh:mm:ss*, enclosed in quotation marks), and a carriage return. The data is written using ASCII text, and each data value is separated by a comma.

Sample Exponential Data File

```
"Snap-Master Data File",17                                          Introduction
"COMMENT$",9,=A comment                                             Comment Line
"DATE$",12,="04-21-1992"                                  Parameter Variables and Values
"TIME$", 10, ="15:38:45"
"ACT.FREQ", 2, =10
"ACT.SWEEP", 1, =2
"NCHAN%", 1, =4
"CHAN$[]", 14, =A0, A1, A2, A3
"NUM.POINTS", 3, =20,
"CLOCK.UNITS$", 3, =Sec
"FILE.TYPE$", 30, =Interleaved Analog Exponential
"INTERLEAVE.FACTOR%", 2, =4,
"CONVERSION.POLY$[]", 30, =0 + 1x, 0 + 1x, 0 + 1x, 0 + 1x
"UNITS$[]", 26, =Volts, Volts, Volts, Volts
"DEFAULT.LABEL%[]", 10, =1, 1, 1, 1
"CHANNEL.LABEL$[]", 34, =Voltage, Voltage, Voltage, Voltage
"CHANNEL.TYPE$[]", 14, =yt, yt, yt, yt
"CHANNEL.RANGES[]", 38, =(-10,10), (-10,10), (-10,10), (-10,10)
"DATAINFO$[]",126,=Board Type: DAS-16
Clock Type: Internal
Trigger Type: Free-Running
Resolution: 12-Bit
"TR", 1                                                             Frame Header
"04-21-1992","15:38:45",
0, -2.5, -1.25, -5                                                  Data
0.0195312, -2.48047, -1.23047, -4.98047
0.0390625, -2.460938, -1.210938, -4.960938
0.0585938, -2.441406, -1.191406, -4.941406
0.078125, -2.421875, -1.171875, -4.921875
0.0976562, -2.402344, -1.152344, -4.902344
0.117188, -2.382812, -1.132812, -4.882812
0.13672, -2.363281, -1.113281, -4.863281
0.15625, -2.34375, -1.09375, -4.84375
0.175781, -2.32422, -1.07422, -4.82422
0.195312, -2.304688, -1.054688, -4.804688
0.214844, -2.285156, -1.035156, -4.785156
0.234375, -2.265625, -1.015625, -4.765625
0.253906, -2.246094, -0.9960938, -4.746094
0.273438, -2.226562, -0.9765625, -4.726562
0.29297, -2.207031, -0.9570312, -4.707031
0.3125, -2.1875, -0.9375, -4.6875
0.332031, -2.16797, -0.9179688, -4.66797
0.351562, -2.148438, -0.8984375, -4.648438
0.371094, -2.128906, -0.8789062, -4.628906
"TR", 2                                                             Frame Header
"04-21-1992","15:38:46",
0, -2.5, -1.25, -5                                                  Data
0.0195312, -2.48047, -1.23047, -4.98047
0.0390625, -2.460938, -1.210938, -4.960938
0.0585938, -2.441406, -1.191406, -4.941406
0.078125, -2.421875, -1.171875, -4.921875
0.0976562, -2.402344, -1.152344, -4.902344
0.117188, -2.382812, -1.132812, -4.882812
0.13672, -2.363281, -1.113281, -4.863281
0.15625, -2.34375, -1.09375, -4.84375
0.175781, -2.32422, -1.07422, -4.82422
0.195312, -2.304688, -1.054688, -4.804688
0.214844, -2.285156, -1.035156, -4.785156
0.234375, -2.265625, -1.015625, -4.765625
0.253906, -2.246094, -0.9960938, -4.746094
0.273438, -2.226562, -0.9765625, -4.726562
0.29297, -2.207031, -0.9570312, -4.707031
0.3125, -2.1875, -0.9375, -4.6875
0.332031, -2.16797, -0.9179688, -4.66797
0.351562, -2.148438, -0.8984375, -4.648438
0.371094, -2.128906, -0.8789062, -4.628906
```

Standard Binary Data File Format

Standard Binary data files use the same header as the Exponential format, but the data is stored as interleaved, floating point binary numbers. Generally, this type of data file will replay about four times faster than the Exponential file.

After the header, the Frame Header is written with a "TR" (which indicates a new frame), the frame number, a carriage return, the date the frame was started (in *mm-dd-yyyy* format, enclosed in quotation marks), the time the frame was started (in 24-hour format of *hh:mm:ss*, enclosed in quotation marks), and a carriage return. Immediately before the first data point in each frame, a Sync Byte (Hex value: AA) is written. Each data point is then written as a four-byte single-precision floating point value (Intel 80x87 format, IEEE 754-1985). Each Sample Group contains one data point per each channel, and the channels are written in ascending order.

Length = (4*(# Channels) * (# Sample Points per Channel)) bytes

Sample Group (SG) = (4 * (# Channels)) bytes0

Byte	Bit Range	Description	Assignment
0 to 4	(all)	first channel's value	Range: -1.7e38 to +1.7e38 with minimum precision of 1.7e-38 24-bit floating precision
5 to 8	(all)	second channel's value	(same)
(etc)	(all)	subsequent channels up to last channel minus one	(same)
(SG-5) to (SG-1)	(all)	last channel's value	(same)

If the data file contains frequency domain data, then the data file contains both the magnitude and phase values for each data point. For an FFT.BLOCKSIZE% of 1, the magnitude part is always followed by the phase part for each data point. When Snap-Master writes the data file, the FFT.BLOCKSIZE is equal to the number of data points in the frame. The data in the file is written according to the following format:

Section	Contains
File Header	Introduction Parameter Name and Value List
Data Frame	Frame Header Magnitude Part Phase Part
Data Frame	Frame Header Magnitude Part Phase Part
Data Frame	Frame Header Magnitude Part Phase Part

Sample Standard Binary Data File

```
"Snap-Master Data File",17                                          Introduction
"COMMENT$",9,=A comment                                             Comment Line
"DATE$",12,="04-21-1992"                                  Parameter Variables and Values
"TIME$", 10, ="15:38:45"
"ACT.FREQ", 2, =10
"ACT.SWEEP", 1, =2
"NCHAN%", 1, =4
"CHAN$[]", 14, =A0, A1, A2, A3
"NUM.POINTS", 3, =20,
"CLOCK.UNITS$", 3, =Sec
"FILE.TYPE$", 25, =Interleaved Analog Binary
"INTERLEAVE.FACTOR%", 2, =4,
"CONVERSION.POLY$[]", 30, =0 + 1x, 0 + 1x, 0 + 1x, 0 + 1x
"UNITS$[]", 26, =Volts, Volts, Volts, Volts
"DEFAULT.LABEL%[]", 10, =1, 1, 1, 1
"CHANNEL.LABEL$[]", 34, =Voltage, Voltage, Voltage, Voltage
"CHANNEL.TYPE$[]", 14, =yt, yt, yt, yt
"CHANNEL.RANGES[]", 38, =(-10,10), (-10,10), (-10,10), (-10,10)
"DATAINFO$[]",126,=Board Type: DAS-16
Clock Type: Internal
Trigger Type: Free-Running
Resolution: 12-Bit
"TR", 1                                                             Frame Header
"04-21-1992","15:38:45",
. . . . . .                                                         Binary Data
. . . . . .
"TR", 2                                                             Frame Header
"04-21-1992","15:38:46",
. . . . . .                                                         Binary Data
. . . . . .
```

Fast Binary Data File Format

Fast Binary Data Format (FBDF) files have two main differences from the Standard Binary data files: the data is not scaled and the data in each frame starts at a cluster boundary (which is a property of the disk's format, and is specified by the CLUSTER.SIZE% variable). FBDF files also have an additional CAL.BLOCK parameter in the File Header. This is a binary block of data dependent on the source of the data stored in the file, and is required for rescaling the raw data on playback in Snap-Master.

FBDF files have the same structure as the Standard Binary data files, except that the data in each frame begins at a cluster boundary. The remaining cluster space between the file header and the actual data is filled with zero values. Also, if a data frame does not fill an complete cluster, then the remaining space is also filled with zeros. These zero values do not affect the actual data stored in the file.

The organization of an FBDF file is as follows:

File Header
Frame Header for Frame 1
...zeroes until the cluster boundary
Raw Data
Frame Header for Frame 2
...zeroes until the cluster boundary
Raw Data
(etc)

Comma Separated Variable Data File Format

Comma Separated Variable, or CSV, files are very popular for importing and exporting data between programs. Each of the variables, or channels, is separated by a comma. Each collection of data points is separated by a CRLF (Carriage Return Line Feed).

In most cases, the first line in the file is the header, which consists of the channel names for each of the channels stored in the file. Each channel name is contained in quotation marks. The remaining rows contain floating point data from the instrument, separated by a space.

If the Time (or Frequency) channel is saved, then it will be the first column in the data file. Whether or not the Time Channel is included in the data file is specified by the Save Time Channel checkbox in the Disk Out dialog box.

For frequency domain data, each data point is a set of two floating point numbers separated by a space: the magnitude part and the phase part. If the Time channel is saved, then the frequencies (in Hertz) are written to the file.

Sample CSV Data File

```
TIME (Sec),CH0,CH1,CH2,CH3
0.0000,5.0000,0.0000,0.0000,0.0000
0.0200,4.9900,0.0197,0.0000,0.0000
0.0400,4.9610,0.0785,0.0000,0.0000
0.0600,4.9120,0.1754,0.0000,0.0000
0.0800,4.8430,0.3089,0.0000,0.0000
0.1000,4.7560,0.4770,0.0000,0.0000
0.1200,4.6490,0.6769,0.0000,0.0000
0.1400,4.5250,0.9056,0.0000,0.0000
etc.
```

ASCII Plotter Data File Format

ASCII Plotter files are similar to CSV files, except that the data is separated by spaces. In addition, the number of spaces usually tries to make the data look columnar when printed out. Also, if the Plotter file contains a header line to provide names for the channels, the names must be enclosed in quotation marks.

If the Time (or Frequency) channel is saved, then it will be the first column in the data file. Whether or not the Time Channel is included in the data file is specified by the Save Time Channel checkbox in the Disk Out dialog box.

For frequency domain data, each data point is a set of two floating point numbers separated by a space: the magnitude part and the phase part. If the Time channel is saved, then the frequencies (in Hertz) are written to the file.

Sample ASCII Plotter Data File

```
"TIME (Sec)" "CH0" "CH1" "CH2" "CH3"
0.000000 5.000 0.0000 0.0000 0.0000
0.02000 4.990 0.0197 0.0000 0.0000
0.04000 4.961 0.0785 0.0000 0.0000
0.06000 4.912 0.1754 0.0000 0.0000
0.08000 4.843 0.3089 0.0000 0.0000
0.10000 4.756 0.4770 0.0000 0.0000
0.12000 4.649 0.6769 0.0000 0.0000
0.14000 4.525 0.9056 0.0000 0.0000
etc.
```

Binary Plotter Data File Format

Binary Plotter data files are similar to the ASCII Plotter format, except that the data values are stored as interleaved binary floating-point numbers. As with the ASCII Plotter format, the first line contains header information and raw data begins on the second line.

HEADER

File Offset = 0 bytes
Length = (4 * (# Channels)) bytes
Header End (HE) = 4 * (# Channels) - 1

Note: If only one channel is contained in the data file, then the header ends after byte 3.

Byte	Bit Range	Description	Assignment
0	b7 - b0	File Type	0xCC
1	b7 - b5	Reserved	X
	b4	Time Channel	0 = Present 1 = Not Present
	b3 - b0	Data Type	0 = Y vs. T data 1 = Y vs. F rectangular data 2 = Y vs. F polar data
2 & 3	b15 - b0	# Channels	Integer 0 - 65535
4 to HE	(all)	Not used	contains 0-value bytes

If the data file contains frequency domain data, then each data point consists of two consecutive four byte values, resulting in eight bytes. The first value is the magnitude data, and the second value is the phase data.

DATA

File Offset = (4 * (# Channels)) bytes
Length = (4*(# Channels) * (# Sample Points per Channel)) bytes
Sample Group (SG) = (4 * (# Channels)) bytes

Notes: Each data point is a four-byte single-precision floating point value (Intel 80x87 format, IEEE 754-1985).

Each sample group repeats once for each data point of every channel of every frame. No frame markers are inserted.

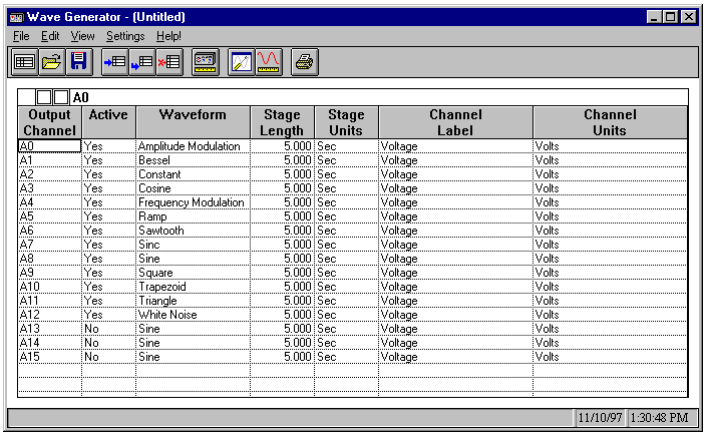
Time channel values (if written) are accumulated across frame boundaries.

Byte	Bit Range	Description	Assignment
0 to 4	(all)	first channel's floating point value	Range: -1.7e38 to +1.7e38 with minimum precision of 1.7e-38 24-bit floating precision
(SG-5) to (SG-1)	(all)	last channel's floating point value	Range: -1.7e38 to +1.7e38 with minimum precision of 1.7e-38 24-bit floating precision

Chapter 5. Wave Generator

5.1. Waveforms **5-2**
5.2. Menu Commands **5-9**
5.3. Tutorial: Creating A Sine Wave **5-10**
5.4. Tutorial: Using Multiple Stages **5-13**

The Wave Generator element provides an easy method of creating both fixed function and arbitrary waveforms. By combining the fixed functions using the multiple stage feature, a wide variety of arbitrary waveforms are available. Data from the Wave Generator can be used for data analysis as well as data output.



Output Channel	Active	Waveform	Stage Length	Stage Units	Channel Label	Channel Units
A0	Yes	Amplitude Modulation	5.000	Sec	Voltage	Volts
A1	Yes	Bessel	5.000	Sec	Voltage	Volts
A2	Yes	Constant	5.000	Sec	Voltage	Volts
A3	Yes	Cosine	5.000	Sec	Voltage	Volts
A4	Yes	Frequency Modulation	5.000	Sec	Voltage	Volts
A5	Yes	Ramp	5.000	Sec	Voltage	Volts
A6	Yes	Sawtooth	5.000	Sec	Voltage	Volts
A7	Yes	Sinc	5.000	Sec	Voltage	Volts
A8	Yes	Sine	5.000	Sec	Voltage	Volts
A9	Yes	Square	5.000	Sec	Voltage	Volts
A10	Yes	Trapezoid	5.000	Sec	Voltage	Volts
A11	Yes	Triangle	5.000	Sec	Voltage	Volts
A12	Yes	White Noise	5.000	Sec	Voltage	Volts
A13	No	Sine	5.000	Sec	Voltage	Volts
A14	No	Sine	5.000	Sec	Voltage	Volts
A15	No	Sine	5.000	Sec	Voltage	Volts

Figure 5-1 Wave Generator

Command Bar

The Command Bar buttons unique to the Wave Generator element are:

Button	Description
	Insert a new stage to the current channel.
	Appends a new stage to the current channel.
	Deletes the current stage.
	Sets the sample rate and frame length.
	Sets the waveform parameters.
	Sets the stage length for the current waveform.

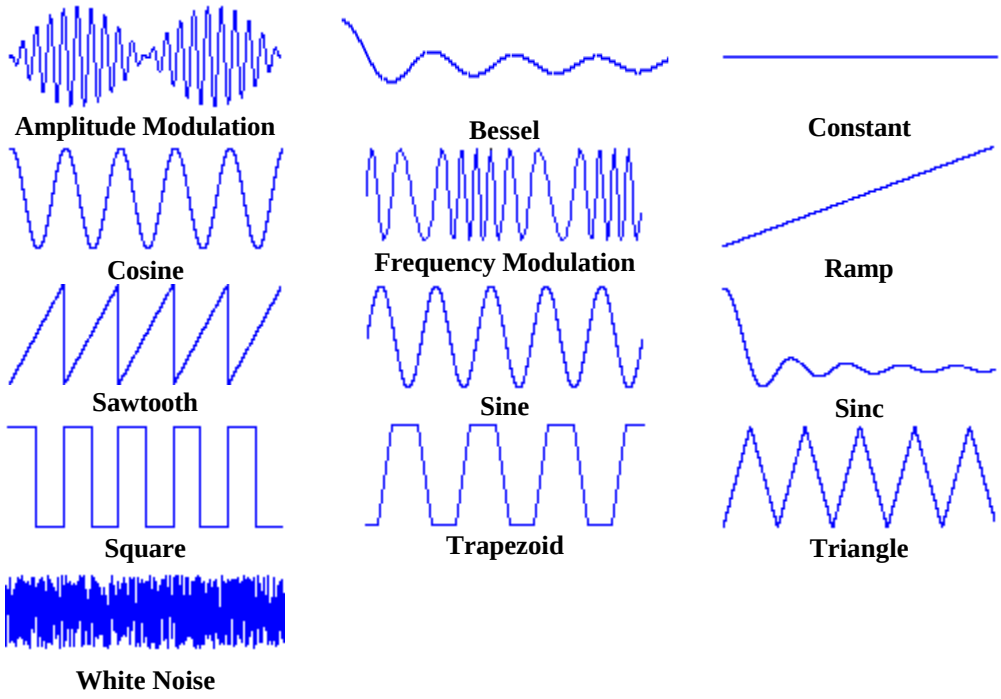
Table Columns

In the Wave Generator table, all columns except the Output Channel column are editable. If you attempt to edit the Output Channel column, you will be informed that editing is not available. The following columns are listed in the Wave Generator table:

Output Channel	The element letter and channel number of the waveform stages.
Active	Specifies if the data for the Output Channel is sent out of the Wave Generator element.
Waveform	Sets the waveform type. Double click on this cell to open the Waveform Settings dialog.
Stage Length	Sets the length of the waveform stage, expressed in Stage Units. Double click on this cell to open the Stage Length dialog.
Stage Units	Specifies the units used to set the Stage Length.
Channel Label	Specifies a long name for the channel. This label accompanies the Output Channel number for use in the Display element and in data files. Editable only in the first line of the channel.
Channel Units	Specifies the units of the Output Channel. The default units are "Volts." Editable only in the first line of the channel.

5.1. Waveforms

The following waveforms are available in the Wave Generator element:



Amplitude Modulation

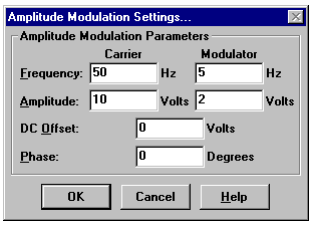


Figure 5-2 Amplitude Modulation Settings

The Amplitude Modulation function varies the amplitude of a single frequency sinusoidal wave (the Carrier) as a function of the magnitude of another single frequency sinusoidal wave (the Modulator). In mathematical terms, the waveform is the result of multiplying the Carrier by the Modulator. To ensure that all of the information in the Modulator signal is retained in the modulated result, the frequency of the Carrier signal should be much higher than the frequency of the Modulator signal.

Frequency	Specifies the frequency of the Carrier sine wave and Modulator sine wave.
Amplitude	Specifies the peak-to-peak amplitude of the Carrier and Modulator sine waves. The overall amplitude of the resulting waveform is the equal to the multiplication of these values.
DC Offset	Specifies the offset from 0 volts for the resulting waveform.
Phase	Specifies the phase shift of the resulting waveform.

Bessel

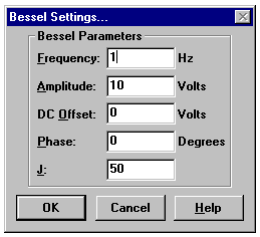


Figure 5-3 Bessel Settings

The Bessel function is often used in frequency modulation to control either the amplitude or frequency of a signal.

Constant

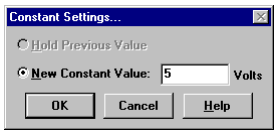


Figure 5-4 Constant Settings

The Constant function produces a straight line "waveform" that maintains a specific value for the duration of the waveform stage. This function is useful when defining the hold stages of a custom ramping waveform.

Hold Previous Value	Uses the last data value from the previous stage for the duration of the current waveform stage.
New Constant Value	Uses the specified value for the duration of the current waveform stage.

Cosine And Sine

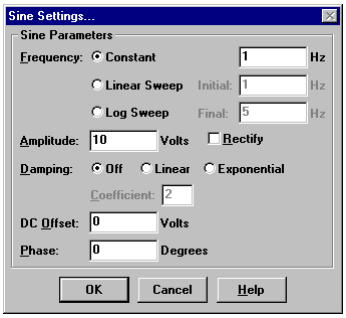


Figure 5-5 Sine Settings

The Cosine and Sine functions generate the traditional trigonometric waveform. There are a number of settings to modify the resulting waveform, including swept frequencies and damping. (Note: To produce a Cosine wave from a Sine Wave, the Phase is shifted by 90°).

Constant	Specifies a single frequency for the duration of the waveform stage.
Linear Sweep	Specifies a swept frequency from the Initial to the Final frequency. The net frequency sweep occurs as a linear function of time for the stage length.
Log Sweep	Specifies a swept frequency for the function from the Initial frequency to the Final frequency. The net frequency sweep occurs as a logarithmic function of time for the stage length.
Amplitude	Specifies the peak-to-peak amplitude of the waveform.
Rectify	Takes the absolute value of the waveform. Any values below zero are negated so the result is positive.
Damping	Varies the amplitude as a Linear (amplitude increases) or Exponential (amplitude decreases) function of time. The damping Coefficient determines the relative damping speed for the stage length.

DC Offset	Specifies the offset from 0 volts for the resulting waveform.
Phase	Specifies the phase shift of the resulting waveform. A Phase change of 90° produces a cosine wave.

Frequency Modulation

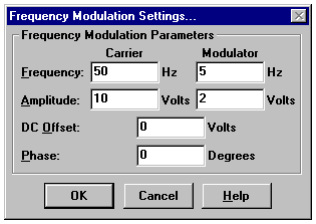


Figure 5-6 Frequency Modulation Settings

The Frequency Modulation function varies the frequency of a single frequency sinusoidal wave (the Carrier) as a function of the magnitude of another single frequency sinusoidal wave (the Modulator). To ensure that all of the information in the Modulator signal is retained in the modulated result, the frequency of the Carrier signal should be much higher than the frequency of the Modulator signal.

Frequency	Specifies the frequency of the Carrier sine wave and Modulator sine wave.
Amplitude	Specifies the peak-to-peak amplitude of the Carrier and Modulator sine waves.
DC Offset	Specifies the offset from 0 volts for the resulting waveform.
Phase	Specifies the phase shift of the resulting waveform.

Ramp

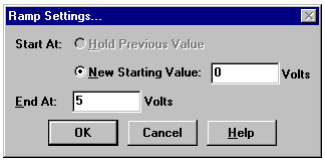


Figure 5-7 Ramp Settings

The Ramp function produces a straight line “waveform” that changes at a constant rate from the Start At value to the End At value for the duration of the waveform stage. The slope of the waveform is determined by the difference between the Start At and End At values and the duration of the waveform stage.

Hold Previous Value	Uses the last data value from the previous stage for the Start At Value of the function.
New Constant Value	Uses the specified value for the Start At value of the function.
End At	Specifies the value of the last data point in the waveform stage.

Sawtooth

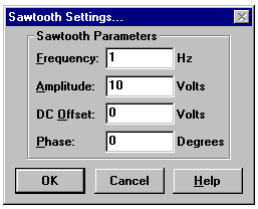


Figure 5-8 Sawtooth Settings

The Sawtooth function produces a waveform which increases at a constant rate from its minimum value to its maximum value, then resets to the minimum value.

Frequency	Specifies the frequency of the sawtooth waveform.
Amplitude	Specifies the peak-to-peak amplitude of the waveform.
DC Offset	Specifies the offset from 0 volts for the resulting waveform.
Phase	Specifies the phase shift of the resulting waveform.

Sinc

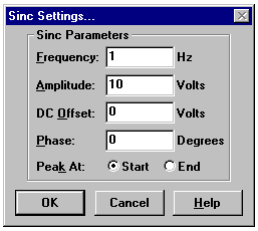


Figure 5-9 Sinc Settings

The Sinc function produces a waveform which is defined as one at time equals zero (scaled by the amplitude), and is equal to sin*x*/*x* for the remainder. the beginning of each cycle increases at a constant rate from its minimum value to its maximum value, then resets to the minimum value.

Frequency	Specifies the frequency of the sine wave portion of the waveform.
Amplitude	Specifies the peak-to-peak amplitude of the sine wave portion of the waveform.
DC Offset	Specifies the offset from 0 volts for the resulting waveform.
Phase	Specifies the phase shift of the resulting waveform.
Peak At	Specifies if the sinc function is at its maximum (relative time equals zero) at the Start or the End of the cycle.

Square

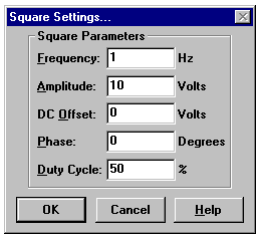


Figure 5-10 Square Settings

The Square function produces a waveform which oscillates between its minimum and maximum values. The oscillation occurs at the specified frequency, with the Duty Cycle determining the amount of time the function is at its maximum value within one cycle.

Frequency	Specifies the frequency of the waveform.
Amplitude	Specifies the peak-to-peak amplitude of the waveform.
DC Offset	Specifies the offset from 0 volts for the resulting waveform.
Phase	Specifies the phase shift of the resulting waveform.
Duty Cycle	Specifies the amount of time the function is at its maximum value within one complete cycle.

Trapezoid

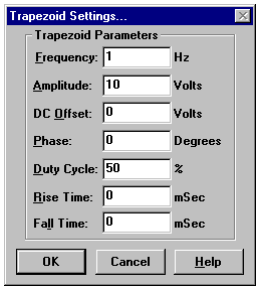


Figure 5-11 Trapezoid Settings

The Trapezoid function produces a waveform which uses defined transition times to oscillate between its minimum and maximum values. The slope of the transition times is defined by the Rise and Fall Time settings.

Frequency	Specifies the frequency of the waveform.
Amplitude	Specifies the peak-to-peak amplitude of the waveform.
DC Offset	Specifies the offset from 0 volts for the resulting waveform.
Phase	Specifies the phase shift of the resulting waveform.
Duty Cycle	Specifies the amount of time the function is at its maximum value within one complete cycle.

Rise Time	Specifies the amount of time when transitioning from the minimum to the maximum value.
Fall Time	Specifies the amount of time when transitioning from the maximum to the minimum value.

Triangle

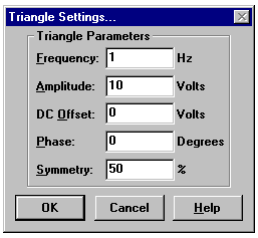


Figure 5-12 Triangle Settings

The Triangle function produces a waveform which oscillates between its minimum and maximum values, with no hold time at the minimum or maximum. The oscillation occurs at the specified frequency, with the Symmetry the relative slopes of the rise and fall times.

Frequency	Specifies the frequency of the waveform.
Amplitude	Specifies the peak-to-peak amplitude of the waveform.
DC Offset	Specifies the offset from 0 volts for the resulting waveform.
Phase	Specifies the phase shift of the resulting waveform.
Symmetry	Specifies the relative slope of the rise and fall times. A value less than 50% means the rise time of the waveform is greater than the fall time. A value equal to 50% means the rise and fall times are equal. A value greater than 50% means the fall time is greater than the rise time.

White Noise

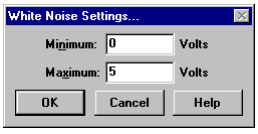


Figure 5-13 White Noise Settings

The White Noise function produces a random noise waveform that moves between the Minimum and Maximum values.

Minimum	Specifies the lowest value for the waveform.
Maximum	Specifies the highest value for the waveform.

5.2. Menu Commands

Please refer to Chapter 2 for a description of the common menu commands.

Edit Menu

Insert Add a new stage in the current channel before the current stage.

Delete Delete the current stage.

Append Add a new stage in the current channel after the current stage.

Settings Menu

Frame Settings...

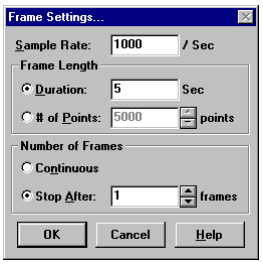


Figure 5-14 Frame Settings

The Frame Settings dialog determines the frame characteristics of all channels in this Wave Generator element.

Sample Rate

The Sample Rate defines how many times per second the Wave Generator element generates a value for each channel. The X-axis units are always defined in “Seconds” and the X-Axis Label defined as “Time”.

A high sample rate for the Wave Generator produces high resolution data internally in SnapMaster, but this does not make the output hardware run any faster. If you are outputting data generated by the Wave Generator using D/A or Digital Out hardware, the output rate of the hardware element determines the final resolution of the data.

Frame Length

Defines the size of each data frame. At each frame boundary, the Wave Generator element resets and restarts the waveforms from the beginning.

Number of Frames

The Number of Frames group allows you to specify how the element operates in the instrument. When the Continuous option is selected, the instrument will continuously generate data frames until the user presses the Stop button. To have the instrument generate a specific number of data frames, select the Stop After option and type the number of frames in the Stop After text field.

Waveform Settings... Define the current parameters for the selected waveform stage.

Stage Length...

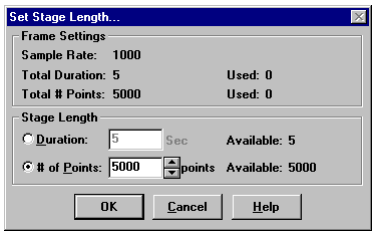


Figure 5-15 Stage Length Settings

Each channel in the Wave Generator element can be composed of multiple waveform "stages" to create a customized waveform. Each stage is set up using the waveform parameters and duration, with the composite waveform for the channel controlled by the order of the stages in the table. By default, each channel has one waveform stage which lasts the duration of the frame.

5.3. Tutorial: Creating A Sine Wave

Building the Instrument

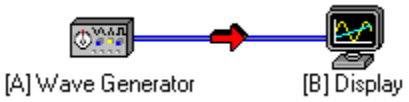


Figure 5-16 Instrument for Wave Generator Tutorial

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place the Wave Generator and Display elements in the instrument.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the Wave Generator element to the Display element.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as WAVEGEN.

Setting Up A Waveform

1. Open the Wave Generator table by double clicking on the element.

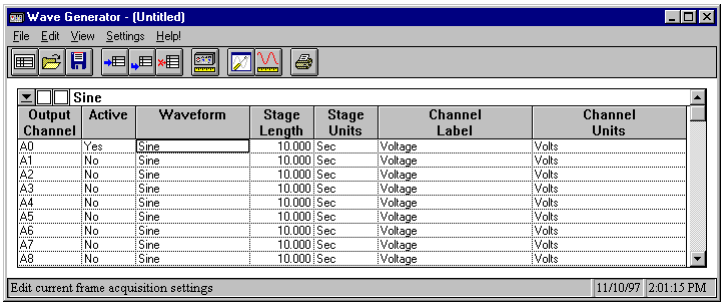

Wave Generator - (Untitled)
File Edit View Settings Help!
Sine
Output Channel | Active | Waveform | Stage Length | Stage Units | Channel Label | Channel Units
A0 | Yes | Sine | 10.000 | Sec | Voltage | Volts
A1 | No | Sine | 10.000 | Sec | Voltage | Volts
A2 | No | Sine | 10.000 | Sec | Voltage | Volts
A3 | No | Sine | 10.000 | Sec | Voltage | Volts
A4 | No | Sine | 10.000 | Sec | Voltage | Volts
A5 | No | Sine | 10.000 | Sec | Voltage | Volts
A6 | No | Sine | 10.000 | Sec | Voltage | Volts
A7 | No | Sine | 10.000 | Sec | Voltage | Volts
A8 | No | Sine | 10.000 | Sec | Voltage | Volts
Edit current frame acquisition settings
11/10/97 2:01:15 PM

Figure 5-17 Wave Generator Settings

Before we set up the sine wave, let's change the sample rate and frame duration for the element.

2. Press the button, or select the Settings menu, Frame Settings command.

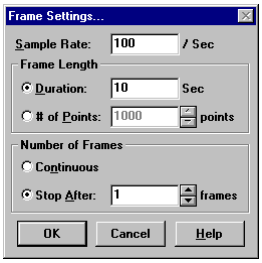


Figure 5-18 Wave Generator Frame Settings

3. Change the Sample Rate to 100.

4. Change the Duration to 10 seconds.

5. Press the OK button to close the Frame Settings.

If you look in the first row (for Channel A0), the Waveform is already set to Sine. Let's see what the parameters are for the sine wave.

6. Position the selection box in the first row then press the button, select the Settings menu, Waveform Settings command, or double click on the Waveform table entry for channel A0.

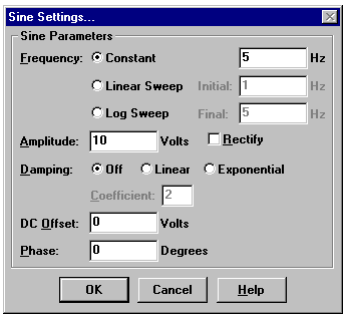


Figure 5-19 Sine Settings

7. Set the Frequency to 5 Hz.

8. Press the OK button to close the Sine Settings.

Now that out sine wave is configured, we need to assign a channel name and activate the channel.

9. Position the selection box in the first row (for Channel A0), Channel Label column and enter *Sine Wave*.

10. Position the selection box in the first row (for Channel A0), Active column. From the pull down list, select "Yes" to activate the channel.

11. Close the Wave Generator table using the File menu, Close Wave Generator command.

Running the Instrument

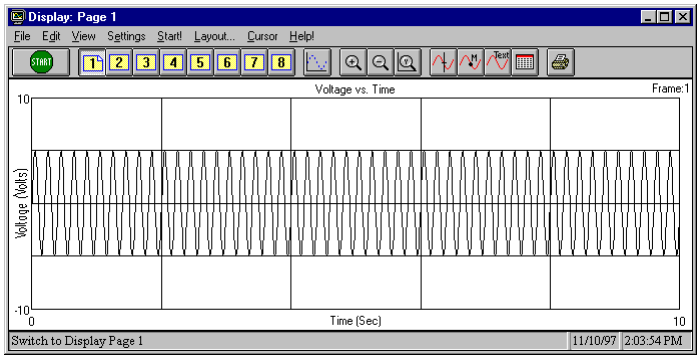


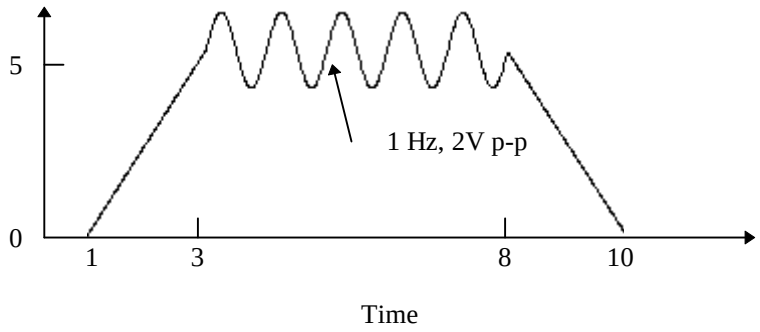
Figure 5-20 Results of Wave Generator Tutorial

When you run the instrument, the sine wave appears as data comes in from the Wave Generator in real time. If a plot for A0 does not appear, insert a new plot using the Display Layout table. If the plot does appear but the data looks fragmented, make sure you are plotting All points in the Plotting Techniques section of the Plot Settings.

5.4. Tutorial: Using Multiple Stages

Now that we have created a simple waveform using the Wave Generator element, let's see how to create a more complex waveform using the stages feature. For this tutorial, we will use the same instrument created in the previous section.

The waveform we are after looks like this:



Breaking the waveform down into pieces, it can be described as follows:

Time	**Description**
0 to 1 sec	0 Volt constant
1 to 3 sec	Ramp to 5 Volts
3 to 8 sec	1 Hz, 2 Volt (peak to peak) Sine wave
8 to 10 sec	Ramp down to 0 Volts

Creating Waveform Stages

1. Open the Wave Generator table by double clicking on the element.

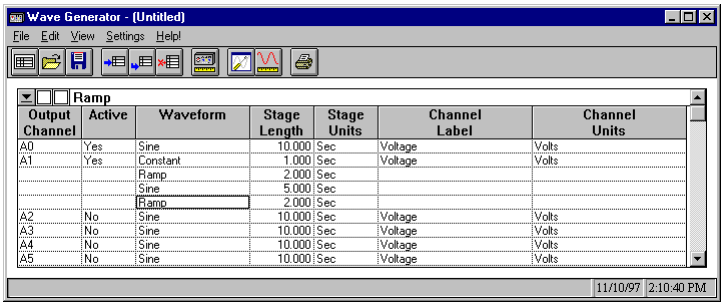

Wave Generator - (Untitled)
File Edit View Settings Help!
Ramp
Output Channel | Active | Waveform | Stage Length | Stage Units | Channel Label | Channel Units
A0 | Yes | Sine | 10.000 | Sec | Voltage | Volts
A1 | Yes | Constant | 1.000 | Sec | Voltage | Volts
Ramp | 2.000 | Sec
Sine | 5.000 | Sec
Ramp | 2.000 | Sec
A2 | No | Sine | 10.000 | Sec | Voltage | Volts
A3 | No | Sine | 10.000 | Sec | Voltage | Volts
A4 | No | Sine | 10.000 | Sec | Voltage | Volts
A5 | No | Sine | 10.000 | Sec | Voltage | Volts
11/10/97 2:10:40 PM

Figure 5-21 Wave Generator Settings For Multiple Stage Tutorial

We will set up the new waveform in channel A1. Using the table we created for the desired waveform, we see that we need a total of four stages for the complete waveform. The first step is to add the stages we need.

2. Position the selection box in the second row (for channel A1) Waveform column, then press the button three times or select the Edit menu, Append Stage command.

Configuring Each Waveform Stage

Now that we have added new stages to the channel, we can set up the waveform and duration for the different stages.

1. Position the selection box in the second row, Waveform column. From the pull down list, select Constant.

2. Press the button, select the Settings menu, Waveform Settings command, or double click on the Waveform table entry for the first stage of channel A1.

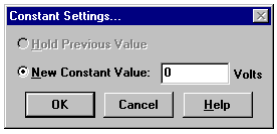


Figure 5-22 Stage 1 (Constant) Settings

3. Change the New Constant Value to 0.

4. Press the OK button to close the Constant Settings.

According to the table, we want the value to remain at 0 for one second, so let's set the duration.

5. Position the selection box in the second row, Stage Length column and enter 1.

Now let's set up the ramp from 0 to 5 volts, which happens between 1 and 3 seconds. This makes our stage length 2 seconds.

6. Position the selection box in the third row, Waveform column. From the pull down list, select Ramp.

8. Press the button, select the Settings menu, Waveform Settings command, or double click on the Waveform table entry for the first stage of channel A1.

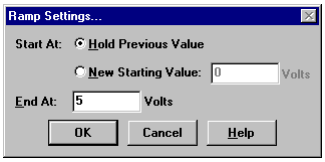


Figure 5-23 Stage 2 (Ramp) Settings

9. Set the Start At to Hold Previous Value.

10. Set the End At value to 5 volts.

11. Press the OK button to close the Ramp Settings.

12. Position the selection box in the third row, Stage Length column and enter 2.

Now let's set up the remaining stages.

13. Position the selection box in the fourth row, Waveform column. If the Waveform is not already set to Sine, select it from the pull down list.

14. Press the button, select the Settings menu, Waveform Settings command, or double click on the Waveform table entry for the first stage of channel A1.

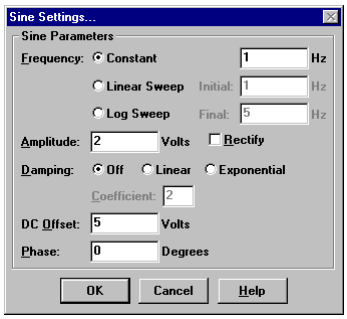


Figure 5-24 Stage 3 (Sine) Settings

The default frequency for a Sine wave is 1 Hz, so we only need to change the amplitude and DC Offset. By setting the DC Offset, we "change" the zero line of the waveform to coincide with where our Ramp function left off.

15. Set the Amplitude value to 2.

16. Set the DC Offset to 5.

17. Press the OK button to close the Sine Settings.

18. Position the selection box in the fourth row, Stage Length column and enter 5.

The sine wave is active between 3 and 8 seconds, so the duration is 5 seconds. Finally we need to ramp the function back down to 0, so we will use the ramp function again.

19. Position the selection box in the fifth row, Waveform column. From the pull down list, select Ramp.

20. Press the button, select the Settings menu, Waveform Settings command, or double click on the Waveform table entry for the first stage of channel A1.

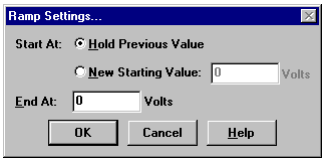


Figure 5-25 Stage 4 (Ramp) Settings

21. Set the Start At to Hold Previous Value.

22. Set the End At value to 0 volts.

23. Press the OK button to close the Ramp Settings.

24. Position the selection box in the fifth row, Stage Length column and enter 1.

Now let's assign a channel name and activate the channel.

25. Position the selection box in the second row (for Channel A1), Channel Label column and enter *Stages*.

26. Position the selection box in the second row (for Channel A1), Active column. From the pull down list, select "Yes" to activate the channel.

27. Close the Wave Generator table using the File menu, Close Wave Generator command.

28. Save the instrument with the button or select the File menu, Save Instrument command.

Running the Instrument

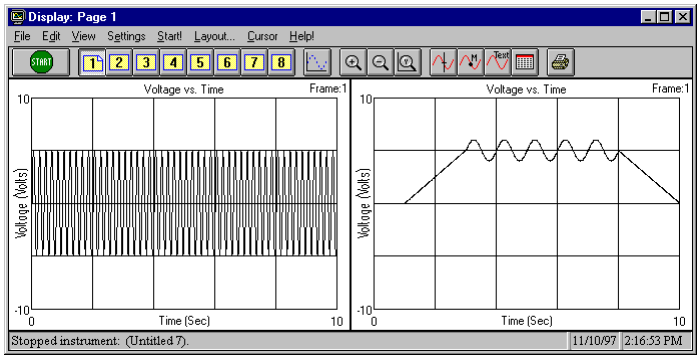


Figure 5-26 Results of Multiple Stages Tutorial

When you run the instrument, the waveform appears as data comes in from the Wave Generator in real time. If the waveform contains large jumps and the data does not appear as shown above, make sure your Hold Previous Value and/or DC Offset settings are correct.

Chapter 6. Dynamic Data Exchange

6.1. DDE In 6-5
6.2. DDE Out 6-8
6.3. Tutorial: Receiving Data In From A Local Spreadsheet 6-11
6.4. Tutorial: Sending Data Out To A Local Spreadsheet 6-14
6.5. Tutorial: Using Block Mode 6-17
6.6. Tutorial: Sending Data To A Spreadsheet Over NetDDE 6-18
6.7. Tutorial: Sending Data To Snap-Master Over NetDDE 6-21

One of the major advantages of Windows is a number of integrated methods for different applications to communicate and share information. The most common methods are the Clipboard and Dynamic Data Exchange (DDE). Both of these methods are supported by Snap-Master.

Clipboard

The Clipboard is the focal point for all data exchange between applications. When you select the Copy, Cut, and Paste commands, the Clipboard becomes the holding place for the information. For the Copy and Cut commands, the currently selected information is sent to the Clipboard, while the Paste command places the contents of the Clipboard in the current application.

The Clipboard supports the basic types of Windows information: text and pictures (also called bitmaps). For example, you can select the Edit menu, Copy command in the Display window to copy the contents of the Display, which is stored in the Clipboard as a picture. When you Paste the picture in another program (such as a word processor, spreadsheet, paint program, etc.), the Clipboard sends the stored picture to the application requesting it. This makes it easy to include information from a number of programs into a central document.

In Windows 3.1, the Clipboard contains only one item at a time. However, in Windows for Workgroups, the Clipboard metaphor is extended to the Clipbook. The Clipbook stores multiple Clipboards as separate pages, similar to a scrapbook.

While the Clipboard is useful for fairly static information, it is still a manual operation for the user to move information from one application to another. Another Windows mechanism for sharing information is Dynamic Data Exchange (DDE), which communicates using links.

Dynamic Data Exchange (DDE)

Dynamic Data Exchange, or DDE, is a step beyond the Clipboard because it automates the transfer of information between applications. This communication is based on a "link" between two applications, which acts as a "personal clipboard" between the applications. DDE is built into the Windows operating environment, so any program that has built-in DDE capabilities can share information with another DDE capable program. DDE is a communication standard for software programs just as RS-232 and GPIB allows different hardware to communicate.

Thus far, the generic term "information" has been used to describe what is being passed between programs. With Snap-Master and DDE, we can now split this out into three distinct categories: commands, parameters, and data. Using DDE, one program can send commands (such as load the instrument, start the instrument, etc.) to control how another application is used. Parameters (such as sample rate, data file name, equation number, etc.) can be changed via DDE to customize the application. Finally, actual data (from an input element, analyzed channels, cursor information, etc.) can be sent between applications.

DDE Clients And Servers

Communication via DDE is accomplished through a link (also called a conversation). The link is initiated by the program requesting the information, and is called the ***client***. The application which provides the information is called the ***server***. Once the link is established, each program can send commands, parameters, and data to the other program.

As an example of a DDE conversation, assume that a word processing document needs the result from a spreadsheet cell. The word processor requests a DDE link (making the word processor the client) with the spreadsheet cell (so the spreadsheet is the server). Once the link is established, the data is transferred from the spreadsheet cell to the word processing document.

While the communication occurs between two programs, there is nothing preventing a third application from listening in. A server can deliver data to multiple clients, and a client can receive data from multiple servers. If you want a single Windows program to act as both a client and a server to another program, there must be at least two separate DDE conversations.

Because DDE is only a mechanism to transfer information between programs, it is up to the destination program to interpret the incoming data. Generally a DDE server application will document how the data is retrieved from it, and the client application documents what types of information it will accept.

DDE Service Names, Topics, And Items

A DDE conversation uses three descriptors to identify the exact information to be transferred from the server. These are the **Service Name** (referred to as the Application in Windows 3.0), the **Topic**, and the **Item**. Once a DDE conversation has been initiated, neither application can change the service name or topic, but the conversation can consist of many different Items.

The Service Name is the name of the application that the client application is talking to. Each server must have a unique application name, and the server application must be running in order to complete the communication. Example Service Names are "Snap-Master", "WinWord" for Word for Windows, and "Excel" for Excel.

The Topic is the subject within the conversation that is addressed by the client. While each application only has one service name, there can be more than one topic within the application. Usually, a topic is a file name, document name (.DOC for Word), worksheet name (XLS for Excel), or some other application specific string. In Snap-Master, the topic is usually defined by the instrument name (.INS).

The last specification of the DDE conversation is the Item. Just like a Service Name may have multiple Topics, each Topic can have multiple Items. An example of an Item is a cell reference within an Excel spreadsheet.

In Snap-Master, Items are subdivided by element, and the Item includes the element letter, a colon, and the Item within the element. For example, the Item for sample rate of the element letter A would be "A:SampleRate". For a complete list of DDE Items for all Snap-Master elements, please refer to Appendix D.

To illustrate the relationship of the components of a DDE conversation, let's draw an analogy between DDE and a telephone number. The Service Name is equivalent to the area code (which determines the region of the country), the Topic is the phone number (which specifies the actual phone location), and the Item is the information discussed with the person on the other end of the line.

As an example, assume that you want to change the Sample Rate of element A to 100 Hz. For the telephone equivalent, say you are calling HEM Data with the instruction "Change the Sample Rate of element A in the instrument TEST.INS to 100 Hz." The conversations would look like this:

Service	DDE: Snap-Master Phone: (810)
Topic	DDE: TEST.INS Phone: 559-5607
Item	DDE: A:SampleRate,100 Phone: "Change the Sample Rate..."
Conversation	DDE: "Snap-Master"|"TEST.INS"!"A:SampleRate,100" Phone: (810) 559-5607 "Change the Sample Rate..."

DDE is similar to a phone system, because there is a standard method to contact someone (the area code and phone number), but the actual information discussed depends on the parties involved. The items discussed in the conversation can change, but if you want to change the phone number you are talking to, a new connection must be made.

DDE Link Types

There are three types of DDE links: a Cold (or Manual) link, a Warm link, and a Hot link. The different links define how and when the DDE transfer of data occurs. The conversation contents for all types are the same, but the Client (requesting) application controls the link type.

When the link is a Cold link, the client requests the data from the server only. In other words, the client application polls the DDE server for the data. If the data changes in the server application between requests, the client does not receive the new data until an update command is made by the client.

A Warm link is similar to a Cold link because the Client application must manually request the new data. The difference is in a Warm link, the server notifies the client that the data has changed, but does not actually send the data until the client requests it.

The most automated DDE link type is the Hot link. When the data changes in the server application, the server automatically sends the new information to the client. This way, the data is consistent between the two applications. This is the most automatic of the DDE types, but it also requires the most processing time by the operating system to complete.

DDE And Snap-Master

Now that we have seen how DDE works in general, let's look at how it works with Snap-Master. At the highest level, Snap-Master acts as both a client (requesting information from other applications) and a server (sending data to other applications). The three different types of DDE information supported by Snap-Master include commands, parameters, and data. For a complete list of DDE information supported by Snap-Master, refer to Appendix D.

Commands are used to control the operation of another program. Typical commands in Snap-Master include load the instrument, start the instrument, stop the instrument, and others. Using these DDE commands into Snap-Master, the user can control how and when Snap-Master operates.

Parameters in Snap-Master are divided up by each element. Essentially, a parameter is equivalent to a value defined in a settings dialog box. These include the sample rate, data file name, data file format, as well as others. The available parameters accepted by Snap-Master are also listed in Appendix D.

When commands and parameters are sent to Snap-Master, the other application acts as the client because it initiates the conversation. Note that we often think of the server as the sender of information, but in this case the server is the recipient of the parameter information.

When you combine commands and parameters in another application, you can create a custom human interface to replace Snap-Master's standard element icon and dialog box interface. This is most useful for presenting the user with a familiar interface. The external application could even automate the operation of Snap-Master by defining a sequence of events and sending the commands and parameters over DDE. If you are interested in creating your own custom user interface, refer to Appendix D or contact HEM Data for the availability of the DDE Programmer's Toolkit to help develop your application.

Finally, we come to the actual **data** acquired from or calculated by the Snap-Master elements. There are many reasons to transfer data out of Snap-Master because of the many features offered in other applications. For example, the user may need to store a special value in a central database, or perform report generation. Many of these and other specialized needs are better met by a dedicated program, which is why Snap-Master has the capability to share data with other programs.

In Snap-Master, data can be further categorized into two types: channel data and Cursor/Marker data. Channel data is generated by the input and analysis elements, and is transferred using the DDE out element. This includes data from A/D Boards, the Analysis element, and others. The Cursor and Marker data come from the Cursor Data table in the Display element, which can be transferred over DDE to other applications.

The following table summarizes the DDE conversations supported by Snap-Master.

Info Type	Direction	S-M Method	S-M Role	Link
Parameters	In	Main S-M	Server	Cold
Commands	In	Main S-M	Server	Cold*
Acquired, Calculated Channels	Out	DDE Out	Server	Hot, Warm, Cold
Cursor, Marker Values	Out	Cursor Data Table	Server	Hot, Warm

* Technically, commands are not sent over a cold link, but to the user commands have the same characteristics of a cold link.

DDE And Other Applications

An application must support DDE in order to send and receive information. Most Windows applications support DDE to some extent. For example, Excel acts as either a client (requests data) or a server (sends data). Word for Windows, on the other hand, acts as only a client, which means another application cannot request data from a Word document. If you are creating your own custom application, it is up to the programmer to include DDE capabilities in the program.

For most standard applications, a simple mechanism is used to create a DDE link. This usually comes in the form of a Copy and Paste Link command. To create a link, you would select the data you want to transfer from the server application and issue a Copy Link command (usually located in the Edit menu. This is similar to a standard Copy command, except that the DDE Link information is copied to the Clipboard). Then switch to the client application and perform a Paste Link command to complete the link.

6.1. DDE In

The DDE In element imports data in real time using Dynamic Data Exchange. Data from other applications such as spreadsheets or custom programs can then be used by other Snap-Master elements such as Analysis, Display, and D/A. If you are running Snap-Master on a Windows For Workgroups network, you can receive data from Snap-Master running on a different computer.

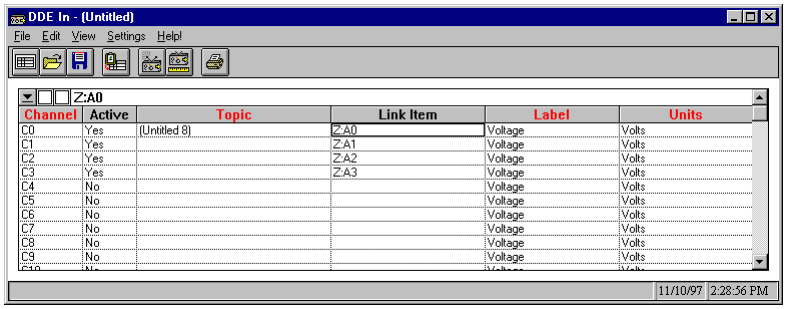

DDE In - (Untitled)
File Edit View Settings Help!
Z:A0
Channel Active Topic Link Item Label Units
C0 Yes (Untitled 8) Z:A0 Voltage Volts
C1 Yes Z:A1 Voltage Volts
C2 Yes Z:A2 Voltage Volts
C3 Yes Z:A3 Voltage Volts
C4 No Voltage Volts
C5 No Voltage Volts
C6 No Voltage Volts
C7 No Voltage Volts
C8 No Voltage Volts
C9 No Voltage Volts
11/10/97 2:28:56 PM

Figure 6-1 DDE In

In order to receive data over DDE, you must include the DDE In element in the instrument. However, you do not need to include the DDE In element if you are only receiving commands and parameters from another application, such as a custom front panel.

The DDE In element acts as a data “client” which receives data from a data “server,” such as a Snap-Master DDE Out element running on another machine or a different application. An instrument can contain multiple DDE In elements (or “clients”) to consolidate data from multiple data servers.

Command Bar

The Command Bar buttons unique to the DDE In element are:

Button	Description
	Sets the DDE Conversation parameters.
	Sets the sample rate and frame length.

Table Columns

In the DDE In Assignments table, the Data Source (set in the DDE Conversation dialog) determines when the table columns are editable (the Channel column is never editable). Columns that are not editable appear with a red column title.

When the data source is Snap-Master, only the Active and Link Item columns are editable. This is because the information in the remaining columns is automatically filled in by Snap-Master. When another application is used as the data source, all parameter columns are editable. The following columns are listed in the DDE In table:

Channel — Specifies the output channel number for the link.

Active — Specifies if the data for the Channel is sent out of the DDE In element. If the channel is active and the specified Link Item is not available, this column contains "N/A" in red text.

Topic — Specifies the data topic for the channel. If Snap-Master is the data server application, then the topic is the file name of the Snap-Master instrument specified in the DDE Conversation dialog. If another application is being used, then this cell is editable by either selecting the topic from the pull down list box (when the Use List To Specify Topics check box in the DDE Conversation dialog is turned on) or by typing the topic name.

Link Item — Specifies the data link for the channel. If Snap-Master is the data server application, then the drop down list contains all available channels from the instrument specified in the DDE Conversation dialog. If another application is being used, then this cell is editable by typing in the appropriate link or by performing a Paste Link command to this cell. (Data is usually presented as a "Hot Link" where the data is updated automatically by the client, or DDE In element.)

Label — Specifies a long name for the channel. This label accompanies the Output Channel number for use in the Display element and in data files. If Snap-Master is the data server application, the label from the source instrument is used and this column is not editable.

Units — Specifies the units of the Channel. The default units are "Volts." If Snap-Master is the data server application, the label from the source instrument is used and this column is not editable.

Menu Commands

Please refer to Chapter 2 for a description of the common menu commands.

Settings Menu

DDE Conversation

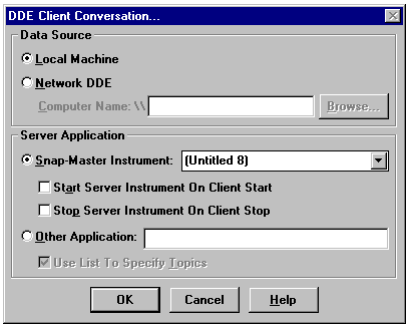


Figure 6-2 DDE Conversation Settings

The DDE Conversation defines the source of the data for the DDE In element. Each DDE In converses with multiple topics and items within an application. If Windows for Workgroups is installed and networking is enabled, then Network DDE (or NetDDE) capabilities are directly supported.

Data Source

The Data Source group only appears when Microsoft Networking is installed and enabled. If this group does not appear, the setting is assumed to be Local Machine.

Local Machine	The data server application is running on the same computer as the Snap-Master.
Network DDE	The data server application is running on the specified **Computer Name**. You may enter the network computer name of the data server machine, or use the Browse button to view the available machines on the Microsoft network.

Server Application

Snap-Master Instrument	When selected, links are automatically created to the specified instrument. When the **Start Server Instrument on Client Start** checkbox is active, the client instrument automatically starts the Snap-Master data server instrument. The **Stop Server Instrument on Client Stop** stops data collection at the server when the client is finished receiving data over DDE. Note: Only one Snap-Master session can run on a single machine so the Snap-Master radio button will be used mostly for instances where the data server is on a separate computer. Multiple DDE In data clients can connect to a single DDE Out data server.
Other Application	When selected, the specified application (such as a spreadsheet or custom program) is used as the data server. When the **Use List To Specify Topics** check box is selected, Snap-Master makes a special DDE request to the “System” topic and Topics item of the application to fill the Topics column drop down list in the table.

Frame Settings

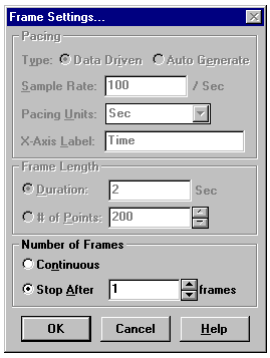


Figure 6-3 Frame Settings

The Frame Settings dialog determines the frame characteristics of all channels in this DDE In element.

When Snap-Master is the Application for the DDE Conversation, the Frame Settings are automatically set by the data server. This makes creating a link with Snap-Master easy by automatically transferring all required information for the data links. The values are not editable but they may still be viewed in this dialog.

Pacing

Data Driven	Waits for each new point from the Item to increment the point count in the frame (this is the setting used when Snap-Master is the DDE Server application).
Auto Generate	Uses the Sample Rate and produces a new point at each specified time interval. This setting is best used when a static value is used for the data link, for example from a spreadsheet cell.

6.2. DDE Out

The DDE Out element allows you to transfer data from Snap-Master to another Windows program via Dynamic Data Exchange (DDE). For example, you could send data from Snap-Master directly to a spreadsheet program to perform special analysis or generate custom reports.

In order to send data over DDE from Snap-Master, you must include the DDE Out element in the instrument. However, you do not need to include the DDE Out element if you are only sending commands and parameters from another application, such as a custom front panel. The DDE Out element is only required if you are sending information from Snap-Master to another application.

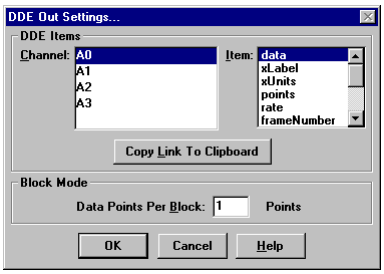


Figure 6-4. DDE Out Settings

The DDE Out Settings dialog provides an easy method of creating DDE Links between Snap-Master and other applications. In addition, the Block Mode allows you to send data in larger chunks, to send data into multiple spreadsheet cells, or to increase the throughput of Dynamic Data Exchange.

DDE Items

To transfer data between Snap-Master and another application, we must create a DDE link. For Snap-Master, this means creating a DDE link from the DDE Out Settings dialog box. A DDE link with the DDE Out element consists of two pieces of information: the Channel and the Item.

To create a link, select both a Channel from the Channel list and an Item from the Item list, then press the Copy Link to Clipboard button. The proper DDE information is automatically copied by Snap-Master to the Clipboard.

To complete the DDE link, switch to the program you want to share information with and perform a Paste Link command. The procedure for this operation varies between programs, but it is usually a variation on the Edit menu, Paste command found in most Windows programs.

(Note: Only Time or Frequency domain channels may be copied; result channels from the Histogram and Conditional element are not currently supported. Also, the maximum length of the DDE Topic string (which includes the full path and name of the instrument) is 100 characters.)

For each channel in Snap-Master, there are a number of items that can be sent over DDE. The available information for each channel is listed in the Items list in the DDE Out dialog box. The following items are available:

data	Transfers the data from the channel. Time domain data is sent separately as a text string. Frequency domain data is sent as magnitude and phase, separated by a comma. The number of frequency domain data points sent over DDE is equal to half the Window Width setting.
xLabel	Transfers the label of the X-axis associated with the channel. For example, time-based signals usually have an xLabel value of "Time", and frequency-based signals have an xLabel of "Frequency".
xUnits	Transfers the units of the X-axis associated with the channel. For example, time-based signals usually have an xLabel value of "Secs", and frequency-based signals have an xLabel of "Hz".

points	Transfers the number of points per data frame for the channel. All channels with the same element letter have the same number of points per data frame.
rate	Transfers the acquisition or calculation rate of the channel. Each channel in Snap-Master has an associated rate used for processing purposes. For example, the rate for channels originating from an A/D Board is equal to the sample rate of the board. For the Analysis element, the rate value is equal to the number of points divided by the duration.
frameNumber	Transfers the current frame number of the channel.
yLabel	Transfers the label of the Y-axis associated with the channel. Custom labels are assigned to a channel with either the Sensor element or the Analysis element. Otherwise, the element letter and channel number are used as the yLabel.
yUnits	Transfers the units of the Y-axis associated with the channel. Custom units are assigned to a channel with either the Sensor element or the Analysis element. Otherwise, the default units of "Volts" are used for the yUnits.
factor	Transfers the factor value of the channel if the Sensor element has assigned a sensor to an incoming channel. If the Disk In element is replaying a file that was scaled with the Sensor element, the factor is still available from the data file.
offset	Transfers the offset value of the channel if the Sensor element has assigned a sensor to an incoming channel. If the Disk In element is replaying a file that was scaled with the Sensor element, the offset is still available from the data file.
yMin	Transfers the default minimum value for the channel. This is not the statistical minimum for all data in the channel, but is the value passed to the Display element which determines the minimum Y-axis value when Auto Scale is used. For A/D Boards without the Sensor element, the yMin value is the lower value of the channel's input range. If a Sensor is applied, the value is the InMin value from the Sensor Specifications table.
yMax	Transfers the default maximum value for the channel. This is not the statistical maximum for all data in the channel, but is the value passed to the Display element which determines the maximum Y-axis value when Auto Scale is used. For A/D Boards without the Sensor element, the yMax value is the upper value of the channel's input range. If a Sensor is applied, the value is the InMax value from the Sensor Specifications table.

Block Mode

The Block Mode setting allows you to send multiple data points in a single string. This is useful for transferring data into multiple cells in a spreadsheet, or for sending larger blocks of data over DDE at once. Each data point is separated by a Carriage Return, Line Feed (CRLF). The Block Mode Settings only applies to the *data* item.

The default Block Size is one point which means that each data point is sent out as the DDE Out element receives it, appended by a CRLF. When the Block Size is greater than one the DDE Out element queues the data points until the nth point is received, then it sends out the complete string with each data point separated by a CRLF. For example if the Block Size is 20, the DDE Out sends a string containing the 20 previous points when the 20th point arrives. If the Block Size is not an integral multiple of the frame length, the “overflow” points at the end of the frame are filled with a zero value.

The Block Size setting is used for all DDE communications within the DDE Out element. If you include more than one DDE Out in the instrument, each element can have a unique Block Size setting.

6.3. Tutorial: Receiving Data In From A Local Spreadsheet

This tutorial discusses how to create a simple DDE data link sending data from Microsoft Excel to Snap-Master. Of course any DDE-aware Windows application can be used in place of Excel, including other spreadsheets, word processors, databases, or a custom application.

Before continuing the tutorial, make sure that Excel is currently running. If you do not have Excel, you can use any application that sends DDE information. For consistency, this tutorial assumes that Excel is sending the DDE data.

Building the Instrument

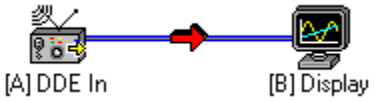


Figure 6-5 Instrument for DDE Out Tutorial

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place the DDE In and Display elements in the instrument.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the DDE In element to the Display element.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as DDEIN.

Configuring the DDE Conversation

1. Open the DDE In Assignments by double clicking on the element.

2. Set the DDE Conversation settings with the button or select the Settings menu, DDE Conversation command.

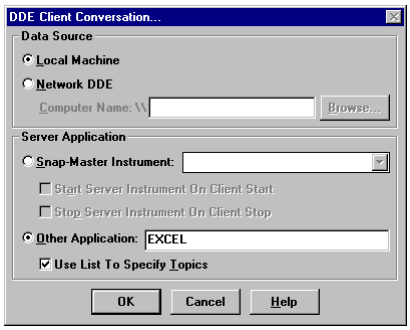


Figure 6-6 DDE In Conversation Settings

3. If the Data Source group appears in the dialog, select Local Machine.

4. Select Other Application for the Server Application, then enter EXCEL in the adjacent text box.

5. Make sure the Use List To Specify Topics check box is selected.

6. Press the OK button to close the DDE Conversation settings.

Setting The DDE In Frame Settings

1. Set the DDE Frame Settings with the button or select the Settings menu, Frame Settings command.

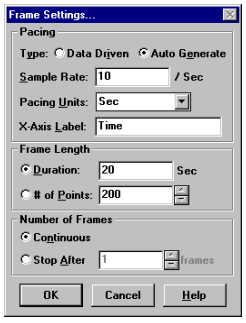


Figure 6-7 DDE In Frame Settings

3. Specify the Pacing Type as Auto Generate.

4. Set the Sample Rate to 10. According to this setting, the Auto Generate function generates a new point using the current value in the DDE Link 10 times per second.

5. Set the Frame Length Duration to 20 seconds.

6. Press the OK button to close the Frame Settings dialog.

Setting Up The DDE In Channel

Now that the link to Excel has been established, we must set up the client to receive the data. Because we are using the list box for the topic, we simply need to select the correct topic from the list and enter the item for the data channel. (In Excel, the topics are defined as the names of the open workbooks and/or sheets).

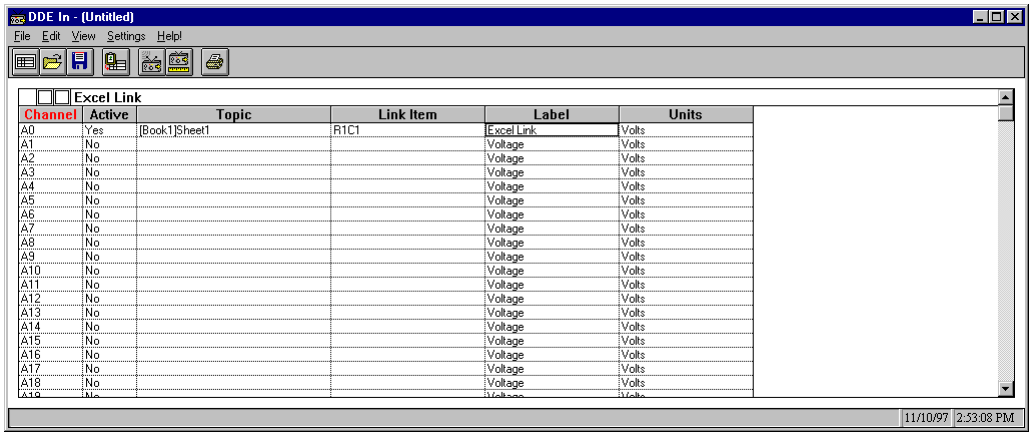

DDE In - (Untitled)
File Edit View Settings Help!
Excel Link
Channel | Active | Topic | Link Item | Label | Units
A0 | Yes | [Book1]Sheet1 | R1C1 | Excel Link | Volts
A1 | No | | | Voltage | Volts
A2 | No | | | Voltage | Volts
A3 | No | | | Voltage | Volts
A4 | No | | | Voltage | Volts
A5 | No | | | Voltage | Volts
A6 | No | | | Voltage | Volts
A7 | No | | | Voltage | Volts
A8 | No | | | Voltage | Volts
A9 | No | | | Voltage | Volts
A10 | No | | | Voltage | Volts
A11 | No | | | Voltage | Volts
A12 | No | | | Voltage | Volts
A13 | No | | | Voltage | Volts
A14 | No | | | Voltage | Volts
A15 | No | | | Voltage | Volts
A16 | No | | | Voltage | Volts
A17 | No | | | Voltage | Volts
A18 | No | | | Voltage | Volts
11/10/97 2:53:08 PM

Figure 6-8 DDE In Assignments

1. Position the selection box in the first row, Active column. Using the drop down list in the upper corner of the table, select “Yes” from the list.

2. Position the selection box in the first row, Topic column. Using the drop down list, select channel “[Book1]Sheet1” (or the name of your spreadsheet document) from the list. If no items appear in the list, make sure that Excel is running. (If you are using a different spreadsheet and the topic names do not appear in the list, turn off the Use List To Specify Topics checkbox in the DDE Conversation dialog and enter the topic name manually.)

3. Position the selection box in the first row, Link Item column and type *R1C1* (or the cell where the data is located).

4. Position the selection box in the first row, Label column and type *Excel Link*.

5. Close the DDE In Assignments using the File menu, Close DDE In command.

6. Save the instrument with the button or select the File menu, Save Instrument command.

Running the Instrument

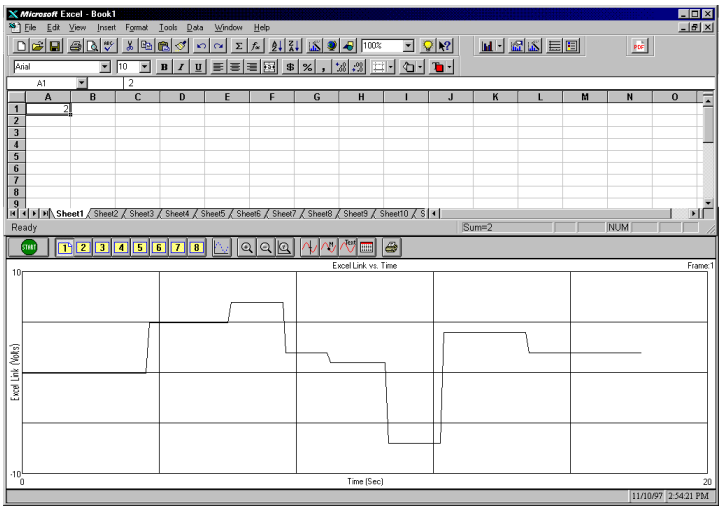


Figure 6-9 DDE Data Transfer from Excel to Snap-Master

Try to size the Snap-Master Display window and the Excel window so you can view both at the same time. To start the instrument, switch to the Snap-Master Display and press the Start! button. While the instrument is running switch to Excel and change the value in the cell specified for the link item. As you change the values, the plot in Snap-Master keeps up with your changes.

Remember that in Auto Generate mode (set in the Frame Settings), the DDE In element generates a new data value at each interval specified for the Sample Rate. In Data Driven mode, a new point is generated by the DDE In element only when the data in the link changes. Try experimenting by changing the Pacing mode to Data Driven to see this effect.

6.4. Tutorial: Sending Data Out To A Local Spreadsheet

This tutorial discusses how to create a simple DDE data link sending data from Snap-Master to Excel. Of course, any DDE-aware Windows application can be used in place of Excel, including other spreadsheets, word processors, databases, or a custom application.

Before continuing the tutorial, make sure that Excel is currently running. If you do not have Excel, you can use any application that accepts DDE information. For consistency, this tutorial assumes that Excel is receiving the DDE data.

Building the Instrument

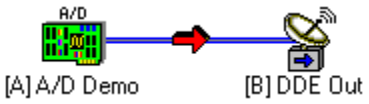


Figure 6-10 Instrument for DDE Out Tutorial

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place the A/D Demo and DDE Out elements in the instrument.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the A/D Demo element to the DDE Out element.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as DDEOUT.

Configuring the A/D Demo

1. Open the A/D Demo Settings by double clicking on the element.

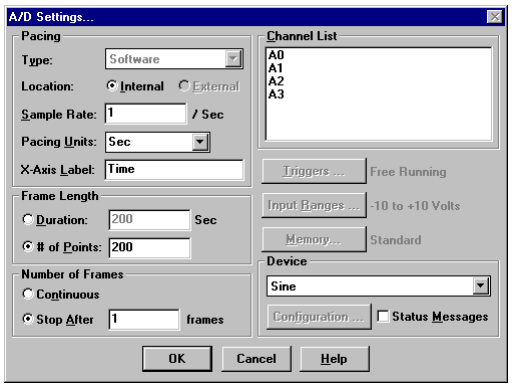


Figure 6-11 A/D Demo Settings

2. Change the Sample Rate to 1.

3. Change the Number of Frames to Stop After 1 frame.

4. Press the OK button to close the A/D Demo Settings.

Copying the DDE Link

1. Open the DDE Out Settings by double clicking on the element.

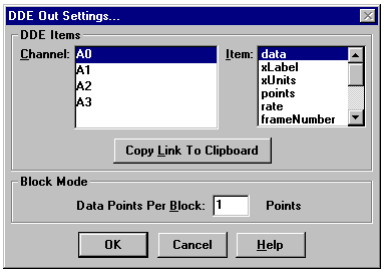


Figure 6-12 DDE Out Settings

2. Select channel A0 from the Channel list.

3. Select *data* from the Item list. The *data* Item contains the value for each data point in the channel.

4. Press the "Copy Link To Clipboard" button. This copies the information necessary for a DDE Link to the Clipboard.

5. Press the OK button to close the dialog box.

6. Switch to Excel.

7. Position the selection box in the cell you want the data to appear in.

8. Select the Edit menu, Paste Special command. Set the Source To Paste Link the Text, then select OK. The value of the cell should change to "?", "#N/A", "#REF", or a number to show that the DDE Link is initialized.

If you are using any other DDE-compatible program, an equivalent Paste Link should be available (for example, in Microsoft Word it is Paste Special, then Paste Link). Consult your program's documentation for instructions on defining a DDE Link.

9. Repeat steps 2 through 7 for the *data* of channel A1, then the *rate* of channel A1. Paste link the information into separate cells in Excel.

Running the Instrument

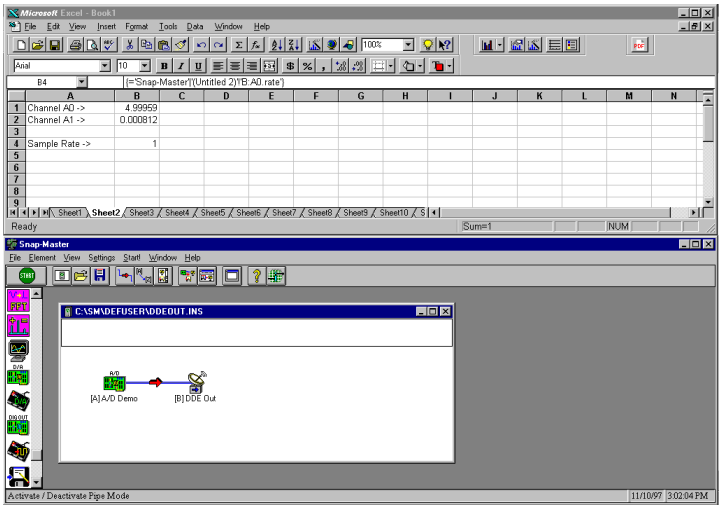


Figure 6-13 DDE Data Transfer from Snap-Master to Excel

Try to size the Snap-Master window and the Excel window so you can view both at the same time. To start the instrument, switch back to Snap-Master and press the Start! menu command. About once every second, a new value appears in the Excel cells you linked to. This information is passed from the A/D Demo element, through the DDE Out element, and finally to Excel.

6.5. Tutorial: Using Block Mode

Now that we have seen how one data point is transferred into a cell, how do we paste data into a column? One way in Excel is to write a macro using the ON.DATA function. This function performs a set of commands when a new data point is sent over a DDE Link. But that requires learning how to write Macro code.

Luckily, there is an easier way to move data into a column. Using the Block Mode capability of the DDE Out element and the same Copy / Paste Link function from the previous section, we can send entire blocks of data to Excel.

Modifying the Instrument

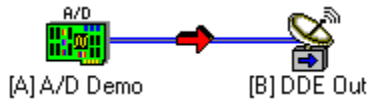


Figure 6-14 Instrument for Block Mode Tutorial

We will use the same instrument from the previous section, changing only one parameter in the instrument. Before we continue, let's save the instrument as a new file.

1. Save the instrument with the File menu, Save Instrument As command. Save the instrument as DDEBLOCK.

Copying a DDE Data Block

1. Open the DDE Out Settings by double clicking on the element.

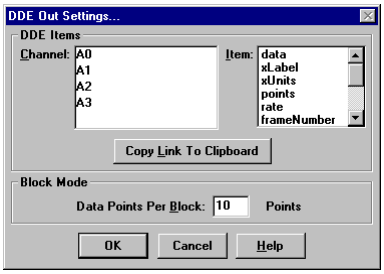


Figure 6-15 DDE Out Settings

2. Select channel A0 from the Channel list.

3. Select *data* from the Item list.

4. Set the Data Points Per Block to 10 points .

5. Press the "Copy Link To Clipboard" button.

6. Press the OK button to close the dialog box.

7. Switch to Excel.

8. Highlight 10 rows in a column, then select the Edit menu, Paste Special command. Set the Source To Paste Link the Text, then select OK. The DDE Links shown in each cell will look identical.

Running the Instrument

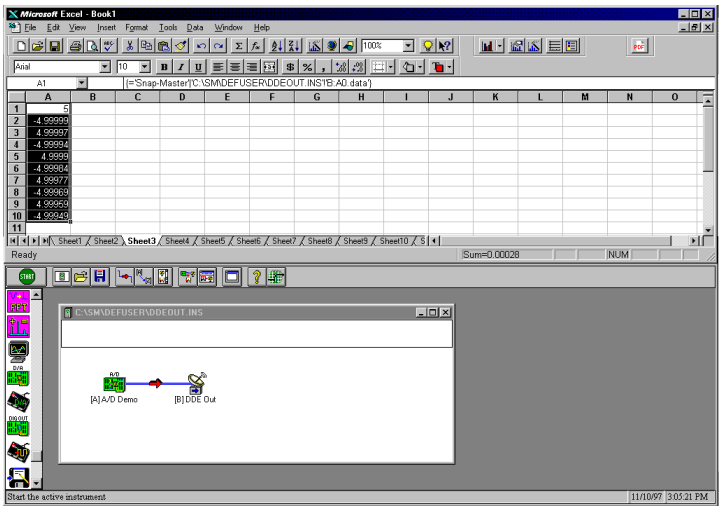


Figure 6-16 Block Data Transfer from Snap-Master to Excel

When you run the instrument from Snap-Master this time, you will see the contents of all cells in the column update simultaneously. When the next block is transferred, the old values are overwritten with the new data.

If you change the Block Size, you will have to perform the Copy / Paste Link again to set up the correct number of cells in Excel. If you specify fewer cells than your Block Size, then Excel truncates the last points because it has nowhere to put the data. If you specify more cells than the Block Size, an "#N/A" appears in the extra cells because there is no data for those cells.

6.6. Tutorial: Sending Data To A Spreadsheet Over NetDDE

Note: This tutorial requires two computers running Windows For Workgroups with sharing enabled on both computers. Only one machine needs to be running Snap-Master, with the other machine running Excel (or another DDE-aware application).

With the inclusion of Network DDE (or NetDDE) in Windows for Workgroups, it is now possible to send data in real time between two computers. NetDDE is essentially the same as DDE on a local machine, except that you can now send data between applications running on separate machines.

In this tutorial, we will use the same instrument created in the previous section. The only difference is in our interaction with the Windows Clipbook.

Setting Up The NetDDE Server

In the NetDDE scheme, the machine that is sending the data (in this case the one running Snap-Master) is called the Server. The Server provides the data which many "Clients" can access. This is analogous to a regular network server which provides a core of files that can be accessed by a number of workstations (or clients).

Just to make sure the DDE Out link is on the clipboard, let's copy it again.

1. Open the DDE Out Settings by double clicking on the element.

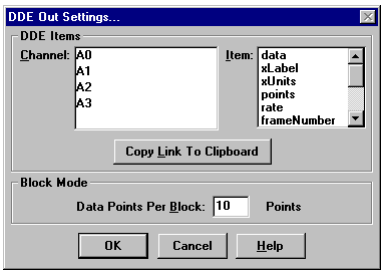


Figure 6-17 DDE Out Settings

2. Select channel A0 from the Channel list.

3. Select *data* from the Item list.

4. Set the Data Points Per Block to 10 points.

5. Press the "Copy Link To Clipboard" button.

6. Press the OK button to close the dialog box.

7. Switch back to the Window's Program Manager, open the Main group, and open the Clipbook Viewer application (the icon looks like this:).

   The Clipbook has two parts: the Clipboard and the Local Clipbook. On the Clipboard, you should see the text "Snap-Master|C:\SM\DEFUSER\DDEBLOCK.ins!B:A0.data" which is the information used for the DDE link. In order to share this information with another computer, we need to copy it to the Local Clipbook.

8. Select the Local Clipbook option from the Window Menu of the Clipbook viewer.

   To add an item to the Local Clipbook, we simply need to perform a Paste command. When you paste to the Local Clipbook, you must specify a Page name for the information and whether or not to share the item.

9. Select the Edit menu, Paste command. Specify a Page name of *dde_test*, and make sure the Share Item Now check box is turned on. When you are done, press the OK button. When the Share Clipbook Page dialog box appears, use the default options and select OK.

   There should now be a new item in the Local Clipbook window which looks like this: dde_test . The hand underneath the page means the item is shared.

Setting Up The NetDDE Client

Now that the Snap-Master data is available on the NetDDE server, let's set up the client to receive the data.

1. If you have not done so, start Excel on the client machine.

2. Open the Clipbook Viewer application on the client machine.

   In order to access the Clipbook on another machine, we must first connect to it.

3. Select the File menu, Connect command.

4. Enter the Computer Name of the server machine (the one running Snap-Master), or select it from the Browse list. When you are done, press the OK button.

   You should now see a window that contains the Clipbook contents on the server with the dde_test item. This means that a valid connection exists. We now need to copy this item to the Clipboard on the client so we can Paste Link it into Excel.

5. Highlight the dde_test item, then select the Edit menu, Paste command.

6. Switch to Excel and highlight 10 cells. Then select the Edit menu, Paste Link command.

   You will see that the item you see in the cell contents does not reference Snap-Master at all. In fact, it shows the computer name and the name of the NetDDE link.

   If all has gone well, you should see either a "?" or an actual data value. If "#N/A" appears, the link may not be correct. In that case, restart the tutorial.

Running the Instrument

When you return to the server and start the Snap-Master instrument, check back on the client machine. You should see the data appear in the Excel cells in real time.

One way to test the throughput of your NetDDE connection is to include a Display element in the Snap-Master instrument. When you run the instrument, there should be no delay between the time the Snap-Master instrument stops plotting data and the Display window menu returns to its normal state. If there is a delay, try lowering the Sample Rate of the A/D Demo or increasing the Block Size of the DDE Out. This decreases the amount of DDE transfers occurring over the network.

6.7. Tutorial: Sending Data To Snap-Master Over NetDDE

Note: This tutorial requires two computers running Windows For Workgroups with sharing enabled on both computers. Both machines need to be running Snap-Master.

In this tutorial, we will use the same instrument created in the previous sections for our data server. Instead of using the Windows Clipbook as we did in the last example, we will utilize the special network communication features of Snap-Master version when bulding our client instrument.

Building the DDE Client Instrument

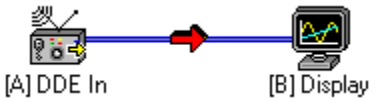


Figure 6-18 Instrument for DDE In Tutorial

This instrument is built on the computer intended as the DDE data client. Multiple clients can access the data from a Snap-Master DDE Out element simultaneously.

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place the DDE In and Display elements in the instrument.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the DDE In element to the Display element.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as DDEIN.

Configuring the DDE Conversation

1. Open the DDE In Assignments by double clicking on the element.

2. Set the DDE Conversation settings with the button or select the Settings menu, DDE Conversation command.

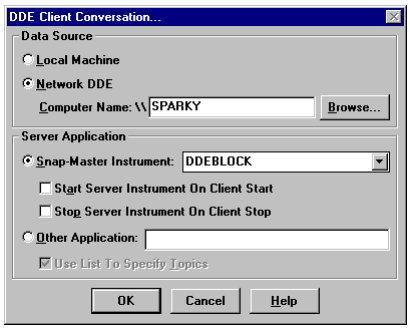


Figure 6-19 DDE In Conversation Settings

3. Select Network DDE as the Data Source.

4. Enter the name of the computer where the DDE data server (the instrument with DDE Out) is running. If you do not remember the computer name, press the Browse button to find it.

5. Select Snap-Master as the Application.

6. Select the instrument DDEBLOCK from the Instrument drop down list.

7. Press the OK button to close the DDE Conversation settings.

Setting Up The DDE In Channels

Now that the link to Snap-Master has been established, we can set up the client to receive the data. Instead of using the Clipbook as we did for Excel in the previous example, Snap-Master has already defined what is available to the DDE In element so we can select items directly from the Assignments table.

1. Position the selection box in the first row, Link Item column.

2. Using the drop down list in the upper left corner of the table, select channel A0 from the list.

   Snap-Master automatically selects the *data* portion of channel A0 and defines the remaining items in the table. Notice that the Label and Units columns are not editable - this is because these settings are transferred directly from the data server. In addition, if you open the Frame Settings using the button, the settings are all grayed out because these are also set from the data server.

3. Close the DDE In Assignments using the File menu, Close DDE In command.

Running the Instrument

When you start the data client instrument (the one with the DDE In), the client checks to see if the data server is running. If the server is not running, the client asks if you want to start the server. When you answer "Yes," the server instrument is started and the data is sent to the Display on the client machine. If you answer "No" then no data will be transferred.

If the server is already running, the Display on the client begins plotting data from the actual frame position of the server. For example if the server is 5 seconds in to a 20 second frame then the client begins plotting data at 5 seconds.

Chapter 7. Sensors & Signal Conditioning

7.1. Sensor Database 7-1
7.2. Sensor Menu Commands 7-4
7.3. Signal Conditioning 7-7
7.4. Tutorial: Adding A Sensor To The Sensor Database 7-8
7.5. Tutorial: Using The Sensor Element 7-10
7.6. Tutorial: Updating a Sensor's Calibration History 7-12
7.7. Tutorial: Additional Sensor Database Hints 7-13

7.1. Sensor Database

The Sensor element performs linear data scaling, conversion to engineering units, and assigning of channel names for incoming data. The integrated Sensor Database provides a central location where you keep track of all of your in-house sensors and transducers, their properties, and a calibration history. The Sensor element is also useful for scaling the output of linear, non-programmable signal conditioning.

NOTES: You only need one Sensor element per instrument.

DO NOT delete all of the Sensors from the database. If you do not want to use the default sensors that come with Snap-Master, add at least one of your own sensors before deleting the default sensors from the database.

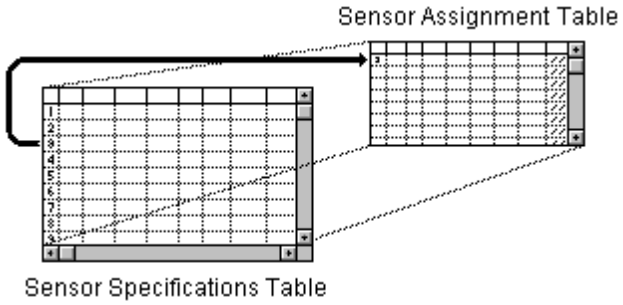


Figure 7-1 Relationship between Sensor Specifications and Assignment Tables

The Sensor element consists of a relational database containing all of the sensors that you own. This database is separated into three tables: the Sensor Assignments table, the Sensor Specifications table, and the Calibration History table. The Sensor Assignments table assigns the sensors from the database to input channels in the instrument, applying the scaling terms and engineering units to the data. The Sensor Specifications table is where you insert, modify, and delete sensors from the database. Finally, the Calibration History contains a separate database for each set of scaling terms and the date when the calibration took place.

The key to the Sensor database is the Sensor ID. Because this is a relational database, the Sensor ID acts as the primary sort index. Each sensor MUST have a unique Sensor ID, which is created when you insert a new sensor from the Sensor Specifications table.

Figure 7-1 displays the relationship between the two key tables in the Sensor element. The Sensor Assignments table takes specific sensors from the Sensor Specifications table and utilizes them in the instrument. Therefore, the Sensor Assignments table acts as an instrument-specific subset of the Sensor Specifications table.

Sensor Database Files

Snap-Master contains only one Sensor database. The files containing the database information are located in the SYSDATA directory and are: HISTORY.DB, HISTORY.PX, SPECS.DB, and SPECS.PX. DO NOT delete these files or move them from this directory.

While there is only one master database, you can have multiple assignment files referencing the same database. The assignments are instrument specific, and always reference the master database. Therefore, your master database can be large, but you will usually assign only a subset of the database in an instrument.

When you want to move instruments or Sensor Assignment files between computers, you must make sure the same Sensor IDs exist on both computers. One way to do this is to copy these four files from SYSDATA and transfer them along with the instrument files.

Input And Output Values And Units

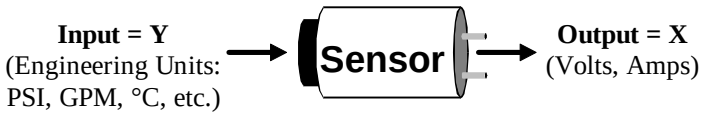


Figure 7-2 Applying Input and Output Ranges to a Sensor

The Sensor element performs linear scaling to incoming channels assigned to a sensor from the database. Expressed mathematically, linear scaling is:

$$Y = mX + b$$

where Y is the result of applying the Factor *m* to the value X and adding the Offset *b*. Given two of the three sets of numbers (*m* and *b* count as one set), you can calculate the unknown values using simple algebra.

In linear scaling there are three sets of numbers to keep track of: the Factor (m) and Offset (b), the Input Range (Ymax and Ymin), and the Output Range (Xmax and Xmin). These values are all listed in the Sensor Assignments and Sensor Specifications tables. But how do these apply to the physical sensor?

The key is to look at the values from the perspective of the sensor. The purpose of the sensor or transducer is to convert some physical event (measured in terms of engineering units) to an electrical value to be read by an A/D converter (usually a voltage). So the input corresponds to the physical events and engineering units, and the output corresponds to the value coming out of the sensor.

Applying this further to the Sensor Database, the Input Minimum is the value going in to the sensor (in engineering units) that produces the Output Minimum value. Conversely, the Input Maximum is the value going in to the sensor that produces the Output Maximum value. From these values, the Factor and Offset values can be calculated by setting up a simple matrix algebra calculation using the $Y = mX + b$ equation. Snap-Master automatically performs this calculation for you in the Sensor Specifications table.

Sensor Assignments

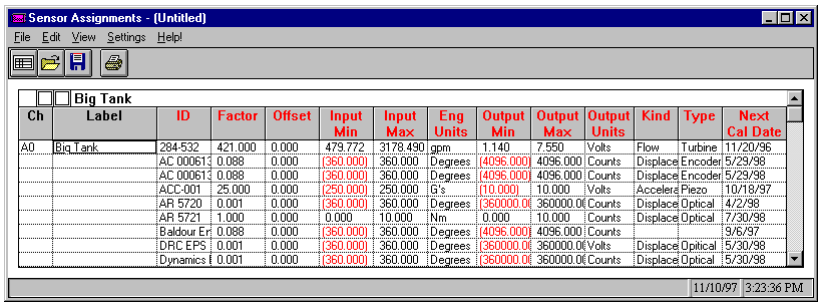

Sensor Assignments - (Untitled)
File Edit View Settings Help!
Big Tank
Ch Label ID Factor Offset Input Min Input Max Eng Units Output Min Output Max Output Units Kind Type Next Cal Date
A0 Big Tank 284-532 421.000 0.000 479.772 3178.490 gpm 1.140 7.550 Volts Flow Turbine 11/20/96
AC 000613 0.088 0.000 (360.000) 360.000 Degrees (4096.000) 4096.000 Counts Displace Encoder 5/29/98
AC 000613 0.088 0.000 (360.000) 360.000 Degrees (4096.000) 4096.000 Counts Displace Encoder 5/29/98
ACC-001 25.000 0.000 (250.000) 250.000 G's (10.000) 10.000 Volts Accelere Piezo 10/18/97
AR 5720 0.001 0.000 (360.000) 360.000 Degrees (360000.0(360000.0(Counts Displace Optical 4/2/98
AR 5721 1.000 0.000 0.000 10.000 Nm 0.000 10.000 Counts Displace Optical 7/30/98
Baldour Er 0.088 0.000 (360.000) 360.000 Degrees (4096.000) 4096.000 Counts 9/6/97
DRC EPS 0.001 0.000 (360.000) 360.000 Degrees (360000.0(360000.0(Volts Displace Optical 5/30/98
Dynamics I 0.001 0.000 (360.000) 360.000 Degrees (360000.0(360000.0(Counts Displace Optical 5/30/98
11/10/97 3:23:36 PM

Figure 7-3 Sensor Assignments Window

The Sensor Assignments window is where you specify which sensor is connected to an input channel and the label for the channel. You can only enter information in the Ch (Channel) and Label columns; the remainder of the information is read from the Sensor Specifications Table (columns with a red title can not be edited).

To assign as sensor from the database, find the ID of the sensor you want to assign, then move the selection box to the Ch column. Pull down the list in the upper left corner of the table, and select a channel from the list. If the channel you want to assign is not listed, it is probably already assigned to a sensor. Channels may only be assigned to one sensor at a time, and each sensor can only be assigned to one channel at a time.

If you assign a sensor that is past the date listed in the Next Cal Date column, an error message appears in the Status Log informing you that a “Sensor ID is out of calibration,” along with the sensor ID. The instrument will operate correctly, but your data may not be accurate due to the possibility that the sensor is out of calibration. Recalibrate the sensor and enter its new values in the Sensor Specifications table, along with a new Cal Date.

Table Columns

In the Assignment table, only the Ch and Label columns are editable. If you attempt to edit any other column, you will be informed that editing is not available for the cell you have selected. To change the value of the other columns, use the Sensor Specifications table. The following columns are listed in the Assignment table:

Ch Specifies the channel which the sensor is connected to. The channel is expressed with the element letter and channel number. Select the channel from the drop down list in the upper left corner of the table. Only one channel may be assigned to each sensor, and a channel may only be assigned once in the table.

Label Specifies a long name for the channel. This label accompanies the default channel designation (such as A0, B4, etc.). This label is used for the default title in the Display element and is saved in data files.

ID The Sensor ID from the database.

Factor The multiplier for the channel to convert from Output units to engineering units. Also known as the “m” term for the linear scaling equation “mX+b.”

Offset The adder for the channel to convert from Output units to engineering units. Also known as the “b” term for the linear scaling equation “mX+b.”

Input Min The minimum value that the sensor can have as an input signal, expressed in Eng Units. Used to define the default Y-axis minimum for the Display element.

Input Max The maximum value that the sensor can have as an input signal, expressed in Eng Units. Used to define the default Y-axis maximum for the Display element.

Eng Units	The engineering units for the sensor, such as °C, PSI, M/S, etc.
Output Min	The output of the sensor when the Input Min value is applied, expressed in Output Units.
Output Max	The output of the sensor when the Input Max value is applied, expressed in Output Units.
Output Units	The units for sensor output, such as Volts or Amps.
Kind	The class of sensor, such as pressure, thermocouple, etc.
Type	The type of sensor, such as Type K, flow, etc.
Next Cal Date	The next date when the sensor is scheduled to be calibrated. If the sensor is used in an instrument past this date, an error is sent in the Status Log.

7.2. Sensor Menu Commands

Please refer to Chapter 2 for a description of the common menu commands.

View Menu

Assigned Shows only those sensors that have been assigned to a channel.

All Shows all available sensors.

Settings Menu

Sensor Specifications

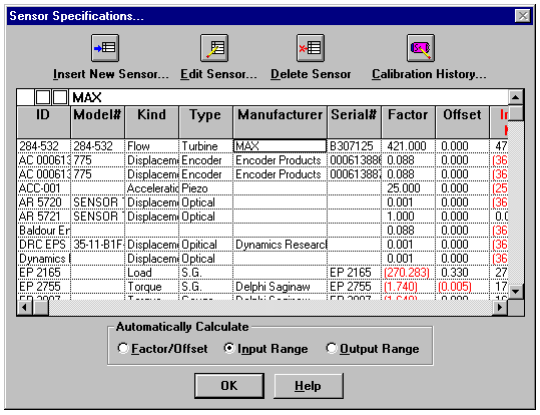


Figure 7-4 Sensor Specifications Dialog Box

The Sensor Specifications is the master table containing the complete Sensor database. From this table, you can insert new sensors into the database, modify the parameters for existing sensors, and delete sensors from the database. If you change the parameters and update the calibration date, the data is stored in into the database and update the calibration history for each. The table is sorted alphabetically by ID.

When inserting or editing a sensor, the Automatically Calculate group determines which values Snap-Master calculates for the $Y=mX+b$ calculation. The item selected can not be edited by the user because Snap-Master is calculating the value for you. When you have a sensor or transducer, you usually know two sets of numbers: either the Factor and Offset, the Input Minimum and Maximum, or the Output Minimum and Maximum. Select the set you do not have in the Automatically Calculate group.

The additional table columns available in the Specifications table are:

Model #	The manufacturer's model number for the sensor.
Kind	The class of sensor, such as pressure, temperature, etc.
Type	The type of sensor, such as thermocouple, flow, etc.
Manufacturer	The name of the sensor manufacturer.
Serial #	Specifies the manufacturer's serial number of the sensor.
Freq Max	The maximum input frequency for the sensor.
Last Cal Date	The last date the sensor was calibrated. The Next Cal Date is equal to the number of days specified in the Interval plus the Last Cal Date.
Cal Interval	The number of days between calibrations for the sensor. The default interval is one day.

Inserting A Sensor

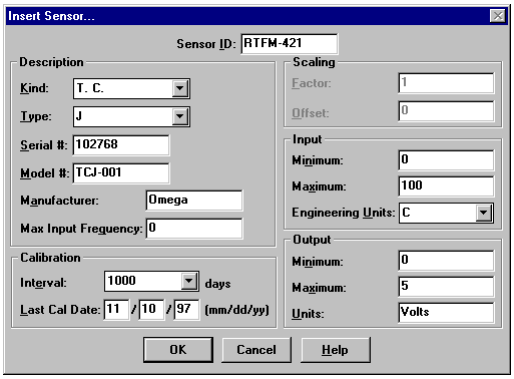


Figure 7-5 Insert Sensor Dialog Box

To add a new sensor to the database, press the Insert New Sensor button . The key piece of information for any sensor is the Sensor ID, so you MUST enter a unique ID from all of the other IDs in your Sensor Database.

The Serial #, Model #, Kind, Type, Manufacturer, and Max Input Frequency is provided solely for informational purposes and does not affect the scaling function. This information is useful for keeping track of the identity of specific sensors when you need to order additional items.

Depending on the selection in the Automatically Calculate group in the Sensor Specifications dialog box, one of the Scaling, Input, and Output groups is disabled. This is to prevent you from inadvertently editing a value that Snap-Master will calculate for you.

An alternative way to add a sensor to the database is to enter a new ID number for an existing sensor in the ID column. The information from the original sensor is copied as a new entry in the database with the new sensor ID. The Specifications table is resorted, and the new entry appears in its proper alphabetical order according to Sensor ID.

Editing A Sensor

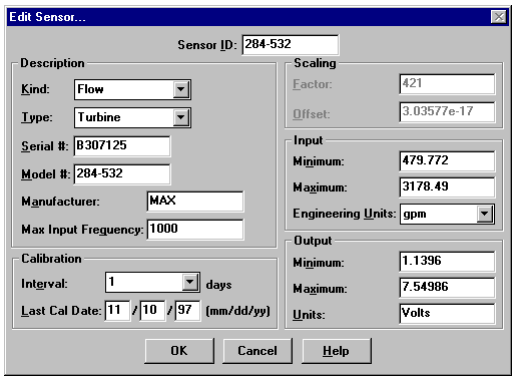


Figure 7-6 Edit Sensor Dialog Box

To edit one or more sensors, select the sensors in the table and press the Edit Sensor button . This dialog works in the same fashion as the Insert Sensor dialog, except that if you change the Sensor ID, a new sensor is created in the database.

Alternatively, you can edit the entries directly in the Sensor Specifications table (except for the columns specified for Automatic Calculation). The changes are written to the database when you move the selection box out of the row of the sensor you are editing, or when you close the Sensor Specifications dialog box.

Calibration History

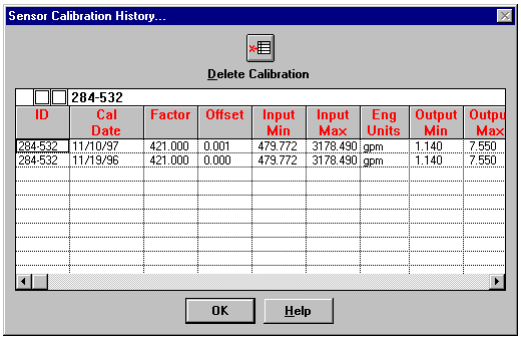
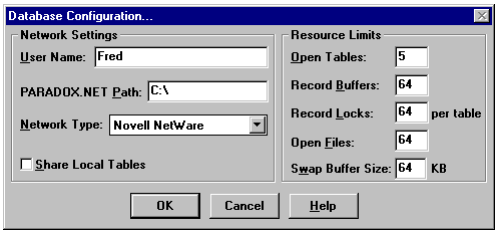


Figure 7.2-7. Calibration History Table

The Sensor Calibration History table contains the list of dates when a sensor was calibrated. To open the table, select the Calibration History button .

When you change the Last Calibration Date, a new entry is added to the Calibration History for that sensor using the current scaling values (remember that the changes are saved in the database when you move the selection box off the row of the sensor). Only one calibration per day is recorded. The Calibration History table is sorted according to the Last Date column, with the most recent calibration dates listed at the top of the table.

Database Configuration



7-8 Database Configuration

The Database Configuration dialog box changes the network and resource settings for the Sensor database. These settings are stored in your WIN.INI file.

NOTE: For most installations, you will not need to change these settings. If you are using any other programs which use the Paradox Database Engine, these settings may already be defined. In most instances, use the default values provided.

The Network Settings group controls how you are identified on the network when sharing database files. The User Name is used to distinguish different computers that are accessing the same database file. PARADOX.NET controls your access to the different databases (only one PARADOX.NET file should be available on your path). Finally, the Network Type defines what type of network you are running on and the Share Local Tables defines if your database files are accessible through the network.

The Resource Limits group defines other settings for database access. In most cases, you can use the defaults with the Sensor Database. For more information on these settings, contact technical support.

7.3. Signal Conditioning

The Signal Conditioning element controls special hardware that amplifies, filters, and performs other signal conditioning functions. In the instrument, the Signal Conditioning element is placed before an input element, such an A/D element. In addition you may also want to use the Sensor database to assign names and additional scaling, so the Signal Conditioning icon is placed between the Sensor and the input element. Like the Sensor, a physical connection must exist between the signal conditioning hardware and the input hardware; the data pipe sends only the scaling information through the instrument.

For information on your specific hardware, please consult the documentation that accompanied your hardware.

7.4. Tutorial: Adding A Sensor To The Sensor Database

Before we use the Sensor element to scale the data of an incoming channel and assign a label, let's add a sensor to the database. All editing of the actual Sensor Database occurs from the Sensor Specifications table. Once the sensor is included in the database, you can assign it any time without having to reenter it.

When you are done entering your sensors in the master list, press the OK button. This will save the changes to the last row you have edited. Also, moving the selection box off of a row writes the last row edited to the database file. The Cancel button cancels only the changes made on the last row you have edited.

Building the Instrument

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place the Sensor element in the instrument.

   If a message box appears on your screen asking you if SHARE.EXE is loaded, you must exit Windows and run SHARE from the DOS prompt (do not run it from a DOS shell within Windows). Refer to the Installation section of the manual for more information.

   To add a new sensor to the database, we need to have the Sensor element in an instrument. We do not need to connect the Sensor to anything right now, so we can simply include the element in a clean instrument window.

Inserting A New Sensor

1. Open the Sensor Assignments window by double-clicking on the Sensor element icon.

2. Select the Settings menu, Sensor Specifications command.

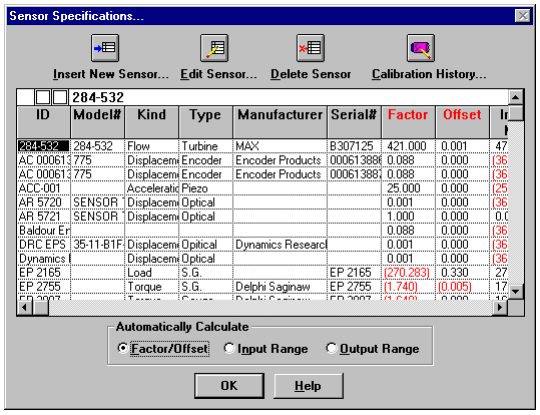

Sensor Specifications...
Insert New Sensor...
Edit Sensor...
Delete Sensor
Calibration History...
284-532
ID
Model#
Kind
Type
Manufacturer
Serial#
Factor
Offset
284-532 284-532 Flow Turbine MAX B307125 421.000 0.001 47
AC 000613 775 Displacem Encoder Encoder Products 000613886 0.088 0.000 (36
AC 000613 775 Displacem Encoder Encoder Products 000613882 0.088 0.000 (36
ACC-001 Acceleratic Piezo 25.000 0.000 (25
AR 5720 SENSOR Displacem Optical 0.001 0.000 (36
AR 5721 SENSOR Displacem Optical 1.000 0.000 0.0
Baldour Er 0.088 0.000 (36
DRC EPS 35-11-B1F Displacem Optical Dynamics Researcl 0.001 0.000 (36
Dynamics I Displacem Optical 0.001 0.000 (36
EP 2165 Load S.G. EP 2165 (270.283) 0.330 27
EP 2755 Torque S.G. Delphi Saginaw EP 2755 (1.740) (0.005) 17
Automatically Calculate
Factor/Offset
Input Range
Output Range
OK
Help

Figure 7-9 Sensor Specifications Dialog Box

3. Select Factor / Offset for the Automatic Calculation.

   When you add a sensor to the database, you need two sets of numbers. The Automatically Calculate group tells the Sensor element which numbers you do not have. If you try to edit the cells that Snap-Master is calculating, a message box tells you that the cells can not be edited.

4. Press the Insert button .

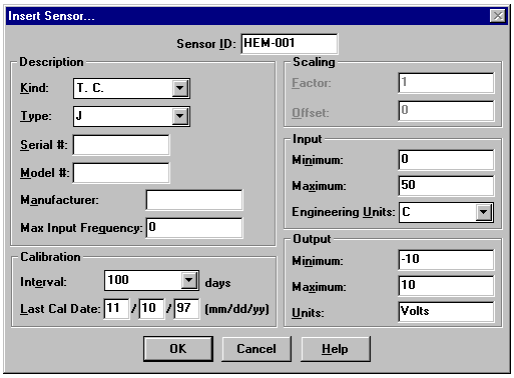


Figure 7-10 Insert Sensor Dialog Box

5. Enter *HEM-001* in the Sensor ID field.

   Remember that the Sensor ID is required because it is the primary sort key for the Sensor Database. This ID must be unique from all other sensors in the database.

6. Set the Kind to *T.C.* (Thermocouple) and the Type to *J*.

   For this example, we are going to set up a type J thermocouple that converts a voltage to a temperature. These items are included in the drop down list, or you can enter your own information. The Kind and Type information has no effect on the actual scaling of the data, but it does help us keep track of the different entries in the database.

7. Set the Calibration Interval to *100* days.

   This interval, along with the Last Cal Date, sets the Next Cal Date for the sensor, which is listed in the Sensor Assignments window. If this sensor is used past the Next Cal Date without being recalibrated, the Status Log will appear and tell you that “Sensor HEM-001 is out of calibration.”

8. Set the Input Minimum to *0*, the Input Maximum to *50*, and the Engineering Units to *C*.

   With these settings, sensor HEM-001 converts voltage to temperature measured in degrees C. With the values we have entered, the factor is 2.5 and the offset is 25.

9. When you are done, press the OK button.

   When you return to the Sensor Specifications table, the database is resorted with the new sensor and it appears in the table in its proper alphabetical order.

   If you want to edit the sensor, you can use the Edit Sensor button , which uses the same dialog as the Insert Sensor dialog. Alternatively, you can edit the settings directly in the table (the F2 key lets you modify the value without retyping it entirely).

10. Press the OK button to close the Sensor Specifications dialog.

11. Select the File menu, Close Assignments command to close the Sensor Assignments table.

12. Select the File menu, Close Instrument command to close the instrument file. You do not need to save your changes.

7.5. Tutorial: Using The Sensor Element

Now that we have included our new sensor in the database, we can use the Sensor element to scale data from the A/D Demo into engineering units, as well as assign a label to the channel. In an instrument, the Sensor element is configured as an input to an acquisition element, usually as an A/D element. This is because in the real world, the sensor converts real world events into analog voltages, which are then converted to a digital signal by the A/D element. Therefore, Snap-Master maintains the logical progression of the test signals in the instrument flow chart by illustrating the Sensor as an input to the A/D element.

Building The Instrument

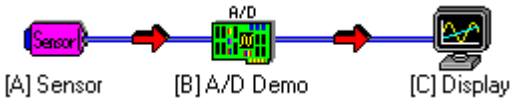


Figure 7-11 Instrument for Sensor Tutorial

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place the Sensor, A/D Demo, and Display elements in the instrument.

> If a message box appears on your screen asking you if SHARE.EXE is loaded, you must exit Windows and run SHARE from the DOS prompt (do not run it from a DOS shell within Windows). Refer to the Installation section of the manual for more information.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the Sensor element to the A/D Demo element, and the A/D Demo element to the Display element.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as SENSOR.

Assigning a Sensor To An Input Channel

1. Open the Sensor Assignments window.

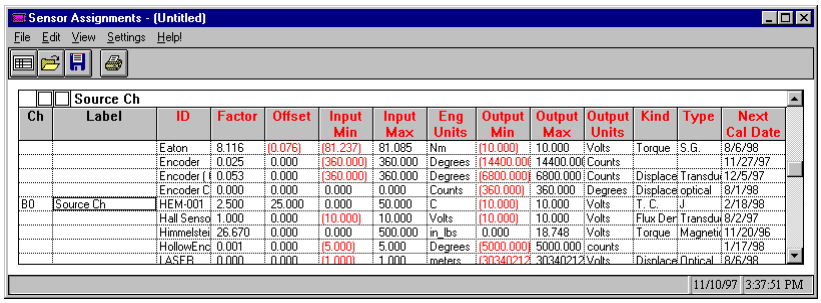

Sensor Assignments - (Untitled)
File Edit View Settings Help!
Source Ch
Ch Label ID Factor Offset Input Min Input Max Eng Units Output Min Output Max Output Units Kind Type Next Cal Date
Eaton 8.116 (0.076) (81.237) 81.085 Nm (10.000) 10.000 Volts Torque S.G. 8/6/98
Encoder 0.025 0.000 (360.000) 360.000 Degrees (14400.000 14400.000 Counts 11/27/97
Encoder (0.053 0.000 (360.000) 360.000 Degrees (6800.000) 6800.000 Counts Displace Transdu 12/5/97
Encoder C 0.000 0.000 0.000 0.000 Counts (360.000) 360.000 Degrees Displace optical 8/1/98
B0 Source Ch HEM-001 2.500 25.000 0.000 50.000 C (10.000) 10.000 Volts T. C. J 2/18/98
Hall Senso 1.000 0.000 (10.000) 10.000 Volts (10.000) 10.000 Volts Flux Der Transdu 8/2/97
Himmelstei 26.670 0.000 0.000 500.000 in_lbs 0.000 18.748 Volts Torque Magnetic 11/20/96
HollowEnc 0.001 0.000 (5.000) 5.000 Degrees (5000.000) 5000.000 counts 1/17/98
LASER 0.000 0.000 (1.000) 1.000 meters (30340212 30340212 Volts Displace Optical 8/6/98
11/10/97 3:37:51 PM

Figure 7-12 Sensor Assignments Window

2. Position the selection box in the Ch column of the row where the ID is HEM-001. Pull down the list in the upper left of the table and select B0 from the list by double clicking on it.

   The Ch column is where you assign the sensor (specified by ID) to an input channel on the A/D Demo. Remember that the A/D Demo is the B element in this instrument and we are acquiring channel 0, hence the B0 assignment.

   When you have multiple channels in an instrument, it is not necessary to assign all of the input channels to a Sensor. For example, if you are using six channels of input data with sensors connected only to channels B0 and B3, you only need to assign those channels to the correct sensor in the database. The remaining four channels are assumed to be directly input to the A/D element.

3. Move the selection box to the Label column in the same row and type *Sample Ch*.

   By assigning a Label to the channel, we can now have a more descriptive name for the channel than simply B0. This label will be passed to the Display element, and will replace the reference to B0 in the Title of the plot.

4. Close the Sensor Assignment window using the File menu, Close Assignments command.

5. Save the instrument with the button or select the File menu, Save Instrument command.

Running The Instrument

Before we start the instrument, let's remove the other plots from the Display window.

1. Double click on the Display element icon to open the Display window.

2. Select the Layout command.

3. Highlight the plots of B1, B2, and B3, then press the Delete button .

4. Press the Close button.

5. Press the Start button

.

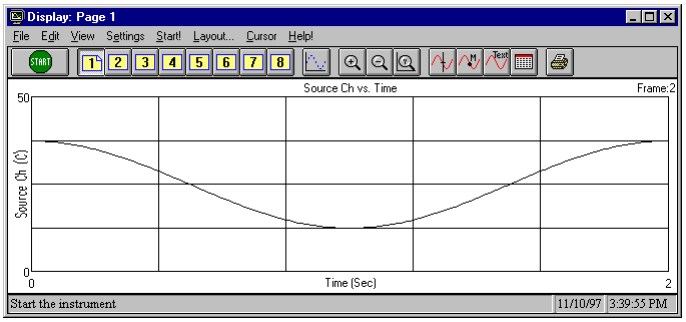


Figure 7-13 Plotting Data Scaled With the Sensor Database

The plot is titled "Sample Ch vs. Time," which reflects our Label assignment in the Sensor element. In addition, the data has been scaled and the engineering units applied. If you use a cursor on this data, you will see that even the Cursor Data window displays the data in engineering units with the Factor and Offset already applied.

7.6. Tutorial: Updating a Sensor's Calibration History

Snap-Master allows you to keep track of the calibration history of each sensor in your sensor database. If you run an instrument with an assigned sensor that is past its next calibration date, an error message appears in the Status Log to inform you that "Sensor ### is out of calibration."

1. Open the Sensor Specifications table using the Specs menu command.

2. Select the appropriate Automatic Calculation variable.

   When you recalibrate a sensor, you usually know the new Input and Output ranges, from which the Factor and Offset are calculated. In this case, select the Factor and Offset as the dependent variables.

3. Update the independent variables in their respective columns.

4. Enter the new calibration date in the Last Cal Date column.

   The calibration history for the sensor is updated when you move the selection box out of the row you are working on, or when you press the OK button.

To view the updated calibration history for a sensor, position the selection box in the row of the sensor, then press the Calibration History button
.

7.7. Tutorial: Additional Sensor Database Hints

Copying An Existing Sensor

If you already have a prototype sensor in the database and you want to copy its settings, simply enter a new ID for the sensor. Instead of changing the ID, a new entry is created in the database. (To make sure any new settings you have made are written to the database, move the selection box off of the row you want to copy, then back again. Remember that changes are written either when you move to a new row or close the Sensor Specifications dialog box with the OK button.)

1. Move the selection box to the ID cell of the sensor you want to copy.

2. Enter the new ID number for the sensor you want to add to the database, then press ENTER.

   The new sensor is entered and the database is resorted so the new sensor appears in its proper alphabetical order.

Hints: If you own a sensor that has multiple uses or input units, specify a different ID number for each function. For example, if you use one sensor to measure PSI for one test and kPa for another test, you could use HEM-101A and HEM-101B respectively as ID numbers.

For non-linear sensors (such as thermocouples) connected to external signal conditioning modules, specify the input range of the sensor and the output range of the signal conditioning module.

Using The Sensor To Assign Channel Labels

It is possible to use the Sensor element simply to scale the Y-Axis values, and assign units and names for plotting using the Display element. All that is needed to accomplish this are a few "mythical" sensors in the database. We will set up sensors with a Factor of 1 and an offset of 0, which results in no scaling of the data.

Follow the same instructions given for adding a sensor to the. Select Factor and Offset for the Automatic Calculation, then set up these values:

ID	Specify a separate ID number for each input channel. We suggest that you use special ID numbers for your mythical sensors.
Input Min	Specify the value you want for the default Y-axis minimum.
Input Max	Specify the value you want for the default Y-axis maximum.
Eng Units	Specify the input channel units.
Output Min	Specify the same number used in Input Min.
Output Max	Specify the same number used in Input Max.
Out Units	Specify the same units used in Eng Units.

Chapter 8. Data Acquisition

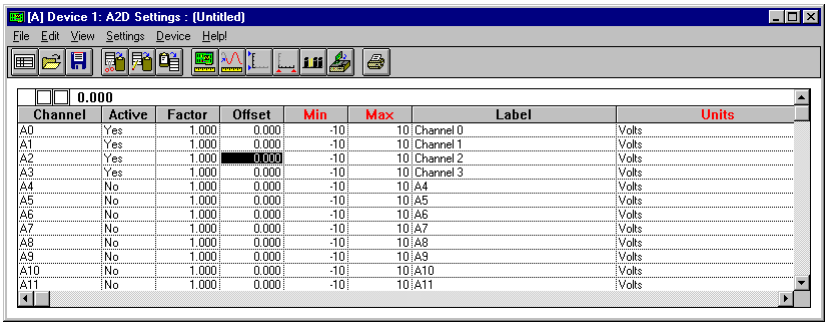
8.1. Analog Input (A/D) **8-1**
8.2. Menu Commands **8-4**
8.3. Digital In **8-13**
8.4. Tutorial: Acquiring Analog Data **8-13**
8.5. Tutorial: Using Triggers to Start Acquisition **8-15**
8.6. Tutorial: Acquiring From Multiple Devices **8-17**
8.7. Tutorial: Acquiring Digital Data **8-21**

The next few chapters describe hardware I/O elements that are the core of Snap-Master's Data Acquisition module. All of the hardware elements (A/D, Digital In, D/A, Digital Out, and Counter Timer) share similarities in their user interface.

There are two possible user interfaces for hardware elements: a table interface and a dialog interface (used in older versions of Snap-Master). You can select which interface you want to use from the Global Settings dialog in the Snap-Master workspace. The table interface is preferred, but there are some older hardware drivers which do not support the table interface.

8.1. Analog Input (A/D)

The A/D element converts analog voltage signals from the real world into digital numbers that can be processed by the computer. Snap-Master allows you to use multiple A/D devices in an instrument. This hardware and all input devices must be properly configured in both hardware and software for proper data acquisition. Please refer to the hardware documentation for information on its features and its use with Snap-Master.



Channel	Active	Factor	Offset	Min	Max	Label	Units
A0	Yes	1.000	0.000	-10	10	Channel 0	Volts
A1	Yes	1.000	0.000	-10	10	Channel 1	Volts
A2	Yes	1.000	0.000	-10	10	Channel 2	Volts
A3	Yes	1.000	0.000	-10	10	Channel 3	Volts
A4	No	1.000	0.000	-10	10	A4	Volts
A5	No	1.000	0.000	-10	10	A5	Volts
A6	No	1.000	0.000	-10	10	A6	Volts
A7	No	1.000	0.000	-10	10	A7	Volts
A8	No	1.000	0.000	-10	10	A8	Volts
A9	No	1.000	0.000	-10	10	A9	Volts
A10	No	1.000	0.000	-10	10	A10	Volts
A11	No	1.000	0.000	-10	10	A11	Volts

Figure 8-1 A/D Settings

Command Bar

The Command Bar buttons unique to the A/D element are:

Button	Description
	Sets the sample rate, frame length, and number of frames.
	Configures the trigger for the element.
	Configures the input range for the element.
	Sets the amount of data retained in the element's buffer using the Memory Settings dialog.
	Configures the base address, interrupt, and DMA settings of the hardware along with other physical jumper settings on the device.
	Associates the installed hardware with Snap-Master device numbers, and shows an overview of the functionality of each installed device.

Table Columns

The following columns are listed in the A/D Settings table:

Channel	The element letter and channel number of the acquired channel. This column is not editable. Some hardware has special rules about which channels you can acquire simultaneously. For example, some hardware requires that you sample all channels between the first and last channels selected (no discontinuous channel numbers). If the channels you specify are invalid for your hardware, Snap-Master automatically resets the selections to an appropriate choice. For more information, please refer to your hardware documentation.
Active	Specifies if the data for the channel is sent out of the element.
Factor	Specifies the multiplier for the channel to convert from volts to engineering units. Also known as the "m" term for the linear scaling equation "mX+b". If you have a sensor assigned to this channel using the Sensor element, this column is not editable.
Offset	Specifies the adder for the channel to convert from volts to engineering units. Also known as the "b" term for the linear scaling equation "mX+b". If you have a sensor assigned to this channel using the Sensor element, this column is not editable.
Min	Shows the minimum value that can be acquired for this channel based on the input range setting and the Factor and Offset values. This column is not editable.
Max	Shows the maximum value that can be acquired for this channel based on the input range setting and the Factor and Offset values. This column is not editable.

Label — Specifies a long name for the channel. This label accompanies the channel number for use in the Display element and in data files. If you have a sensor assigned to this channel using the Sensor element, this column is not editable.

Units — Specifies the units of the channel. The default units are “Volts.” If you have a sensor assigned to this channel using the Sensor element, this column is not editable.

Dialog Interface

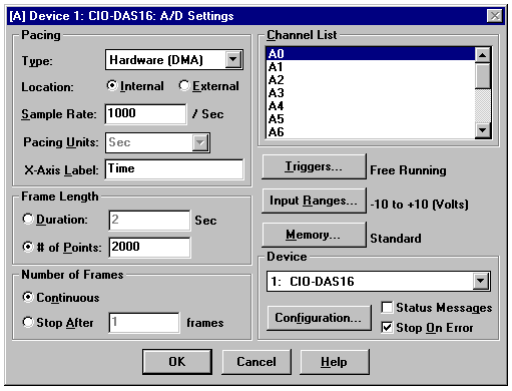


Figure 8-2 Dialog Interface for A/D Settings

The dialog interface for hardware elements is used in older versions of Snap-Master, as well as older hardware drivers. Most drivers are developed using HEM Data's HDI, or Hardware Driver Interface. HDI provides a common user interface so setting up a hardware device is the same regardless of the type or manufacturer of the hardware. Older drivers that do not use HDI will continue to use the dialog interface.

Most of the settings in the table interface have an equivalent dialog control or button. In general, menu commands in the table interface correspond to either a button or a check box in the dialog interface. You can not set the Factor, Offset, Label, and Units directly in the A/D element using the dialog interface - you would need to use the Sensor element to do that.

8.2. Menu Commands

Please refer to Chapter 2 for a description of the common menu commands.

Edit Menu

Reset To Default

Resets the Factor, Offset, Label, and Units to the default values for the selected channels.

Settings Menu

Frame Settings

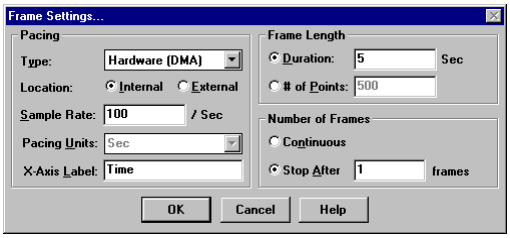


Figure 8-3 Frame Settings

The Frame Settings dialog is used to set up the pacing clock source, sample rate, frame duration, and number of frames for the device.

Pacing

Type

Software pacing relies on the computer's timer to determine when to acquire a new data point, which is limited to a resolution of around 18mS (or approximately 55 Hz). Snap-Master then duplicates measured samples to produce data at the specified Sample Rate.

Hardware pacing uses the clock specified by the Location, which precisely controls the timing of each A/D conversion. With Hardware pacing, the timing between samples is guaranteed. The different types of Hardware pacing include IRQ (interrupt based), DMA (direct memory access), FIFO (on-board memory), and REP INS (repeat input string). These are listed in ascending order of throughput (DMA is faster than IRQ, etc.) If the Type control does not appear, hardware pacing is used.

Location

Specifies if the pacing clock for the A/D hardware. **Internal** uses the timing device on the A/D hardware. When you specify an **External** clock, you must supply the hardware with a TTL pulse-train signal to determine when a sample is acquired. Using an External signal for Pacing is also how asynchronous (non-linear time, or without a time basis) sampling is accomplished.

For information on how your hardware uses External Pacing, refer to the documentation accompanying your hardware.

Sample Rate

Specifies how often the A/D hardware reads data. With an Internal pacing clock, Snap-Master selects the closest sampling rate supported by the hardware.

One of the most perplexing issues for newcomers to analog to digital conversion is the selection of a sampling rate. Nyquist's Sampling Theorem (see Appendix C) states that for an accurate representation of the original signal, the sampling rate must be at least twice that of the highest frequency being sampled. For example, if you were trying to sample signals in the range of human hearing (20 - 20,000 Hertz), you would have to specify a sampling rate of at least 40,000 Hertz in order to accurately represent the entire range. In practice, sampling rates up to 10 times the desired frequency range are used to acquire data with good resolution.

In the real world, there is a limitation to how fast each channel of data can be sampled. This is related to the maximum sampling rate of the A/D board and the number of channels being scanned (referred to as the aggregate sampling rate):

$$\text{Max Sample Rate per Ch} = \frac{\text{Max Hardware Sample Rate}}{\text{Number Chs Sampled}}$$

Pacing Units

Specifies the X-axis units for the element. When the Pacing Units are seconds, the Sample Rate is measured in Hertz.

When an External pacing clock is used, the pacer pulses may have a constant physical unit (such as degrees) associated with each pulse. Use the Units list to select alternate values for the sampling rate, or enter your own in the list. If you cannot associate physical units to the pacer, use a sample rate of 1, and units of "Scan".

X-Axis Label

Specifies the name for the independent axis.

Frame Length

You can define the size of each data frame by specifying either **Duration** (based on the Sample Rate and the Pacing Units) or as an absolute **Number of Points**. The frame length is equal to the number of points divided by the sample rate. A frame is analogous to the sweep time of traditional oscilloscopes.

At the end of each frame, the A/D element reinitializes itself. As a result, there is a break between data frames, the length of which is affected by a number of factors including the speed of the computer, the complexity of the instrument, etc. Therefore, a frame is a contiguous set of gapless data acquired at the specified Sample Rate, with an indeterminate gap between frames. At lower sample rates, the time lapse between frames may be unnoticeable.

Frames are used to separate the data into logical blocks. For example, if you only want to acquire 500 points after an error condition occurs, set up a Trigger to start a frame on the error and set the frame length to 500 points. Otherwise, you would have to wade through a large amount of data to only look at the points of interest. A frame can range in length from 1 point up to 2,147,483,647 points.

Number of Frames

The Number of Frames group allows you to specify how Snap-Master will run the instrument. When **Continuous** is selected, the instrument continuously acquires data frames until the user presses the Stop button. To have the instrument acquire a specific number of data frames, select **Stop After** and enter the number of frames.

For example, if Stop After is selected with a value of 5, Snap-Master will acquire five frames of data and automatically stop the instrument. At any time, the user can stop the instrument manually.

Trigger

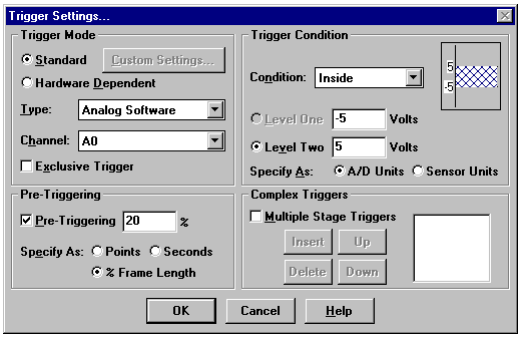


Figure 8-4 Trigger Settings

Triggers are used to start a frame based on a specific characteristic of the incoming data. There are many different options for triggering, which may differ between A/D hardware. Please refer to the documentation accompanying your hardware for information on its triggering capabilities.

The standard software-based is best used at lower acquisition rates. The response of the triggering function depends on the A/D hardware used, the speed of the computer, the complexity of the instrument, as well as other factors. If the trigger condition is not sensed, try lowering the sample rate or using A/D hardware with hardware based triggering capabilities.

Trigger Mode

Standard	Software-based triggering available for all hardware types.
Hardware Dependent	Special triggering capabilities included by the manufacturer specific to this hardware, such as hardware based triggering. To access the special settings for these trigger types, press the **Custom Settings** button.
Type	Snap-Master Standard trigger types include **Free Running** (the frame begins as soon as Snap-Master is ready - essentially no trigger) and **Analog Software** (uses a trigger condition on an incoming analog input channel to determine when a frame starts).
Channel	Specifies the channel used to look for the trigger condition.
Exclusive Trigger	When selected, this element suspends operation of all other elements in the instrument until the trigger condition is met. To bypass any trigger conditions while the instrument is running, press the ESC key.

Trigger Condition

Condition

Specifies the signal characteristic which generates a positive trigger. The standard conditions are as follows:

Condition	# Levels	Description
Above	1	Trigger occurs when the channel data is above Level One
Below	1	Trigger occurs when the channel data is below Level One
Inside	2	Trigger occurs when the channel data is between Level One and Level Two
Outside	2	Trigger occurs when the channel data is outside both Level One and Level Two
Positive Slope	1	When Level One is selected, the Trigger occurs when the previous channel data point is below Level One and the current channel data point is above Level One
	2	When Level Two is selected, the Trigger occurs when the previous channel data point is below Level One and the current data point is above Level Two
Negative Slope	1	When Level One is selected, the Trigger occurs when the previous channel data point is above Level One and the current channel data point is below Level One
	2	When Level Two is selected, the Trigger occurs when the previous channel data point is above Level One and the current data point is below Level Two

Level 1
Level 2

Specifies the levels for the various trigger conditions.

Specify As

Selects if the Level 1 and Level 2 values are specified in **A/D Units** (usually volts) or **Sensor Units** if a sensor is assigned to the channel.

Pre-Triggering

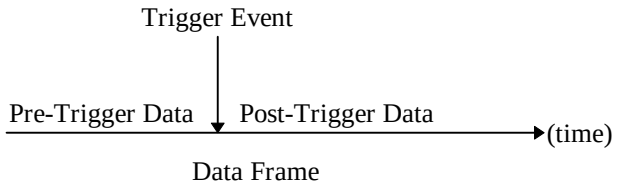


Figure 8-5 Pre / Post Triggering

Pre-Triggering — When selected, specifies the amount of data included in the data frame that occurred immediately before the trigger condition was satisfied.

Specify As — Selects if the Pre-Triggering amount is specified as **Points**, **Seconds** (or X-axis units), or **% Frame Length**. The remaining points in the frame that appear after the trigger event is called "Post-Trigger Data."

By specifying a Pre-Trigger length of the entire frame (or 100%), it is possible to set up a "Trigger To Stop" condition. With this setting, the data will not be available until after the frame is acquired and the trigger condition is satisfied.

The amount of memory specified in the Memory dialog may affect how much Pre-Trigger data is available. If you ask for more pre-trigger data than is available in memory, Snap-Master will use the maximum amount of data available.

Complex Triggers

The Complex Triggers group configures more detailed trigger conditions by cascading multiple stages using the standard types. When the Multiple Stage Triggers check box is turned on, each stage trigger must be satisfied before the acquisition frame begins. Pressing the Insert button adds a new stage to the list with the current settings. The Up and Down buttons rearranges the selected stage in the list, and the Delete button removes the selected stage.

Ranges

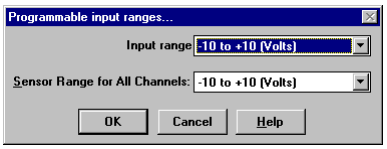


Figure 8-6 A/D Input Ranges - One Range For All Channels

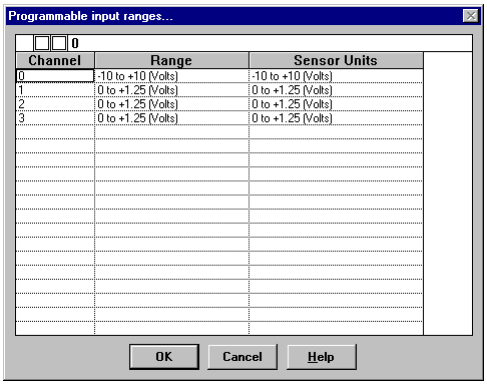


Figure 8-7 A/D Input Ranges - Separate Range Per Channel

If your A/D hardware supports programmable input ranges, the Input Ranges button opens one of the Input Ranges dialog boxes. For hardware that has one programmable input range for all channels, the dialog box shown in Figure 8-6 is used to set the range. For hardware that allows a separate range per channel, the dialog box shown in Figure 8-7 is used, with the range selected from the table's drop down list in the upper left corner.

If your A/D hardware's input range is set by hardware jumpers, a dialog box appears informing you of the current settings.

Memory

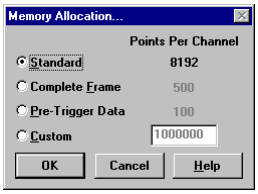


Figure 8-8 Memory Allocation Settings

The Memory Allocation settings determines how many data points per channel are stored in memory. This setting affects the Pre-Triggering function in the Triggers dialog, as well as the Retrace function in the Display element.

NOTE: The Memory Allocation settings are included for advanced users. If you are unsure how to use the different options, the safest selection is to use the Standard setting.

There are four options to set the number of data points stored in memory. (If this button does not appear, the Standard method is used.)

Standard	Stores up to 32,768 points divided by the number of channels. (For example, if four channels are acquired, then 8,192 points per channel are stored in memory.) This is the simplest and safest of all the memory options. If you are having any problems with the number of points available for Retrace, set the Memory Allocation to Standard.
Complete Frame	Stores the number of points specified in the # of Points. The advantage of this setting is it retains the maximum amount of data in memory, but this is also the most memory intensive of all options. This setting will produce more "Out Of Memory" errors in the Status Log than other methods. Only use this setting if you are certain that there is enough memory for the data and have thoroughly tested the instrument running under normal operating conditions.
Pre-Trigger Data	Stores enough data points to satisfy the number of data points specified for the Pre-Trigger length. The same caveats described for the Complete Frame option apply. For this selection, the data available for the Retrace function is equal to the number of points specified for the pre-trigger data, regardless of where the trigger point is located. For example, if the frame length is 1,000,000 points and the Pre-Trigger is 60%, the Pre-Trigger Memory option allocates 600,000 points. When you acquire the data, the trigger point occurs at point 600,000. When you perform a retrace the last 600,000 points are available, which would be from point 400,001 to point 1,000,000.
Custom	Stores a user defined number of data points per channel. The same caveats for memory and retrace described for the Complete Frame and Pre-Trigger options apply.

The absolute maximum number of points allowed is 8 million (divided by the number of channels). Of course, the amount of available memory determines how many data points can be retained. This is determined by the amount of memory installed in the computer and the amount of memory remaining after loading other applications. If an error occurs in the Status Log that not enough memory could be allocated, you will need to lower the amount of data retained in memory. To maximize the performance of the Memory function in Snap-Master, close any other applications to increase the available memory.

As a rule of thumb, do not allocate more than 1/4 your installed physical RAM for A/D memory without testing to make sure the instrument operates without A/D Overruns. Use the actual amount of installed memory, NOT the amount of available memory reported by Windows which may include virtual memory. For example, if your computer has 4 MB of RAM, is should be safe to allocate up to 1 MB for data (approximately 500,000 data points). Above this number, try running the instrument to verify that it operates correctly.

If you are running Windows in 386 Enhanced Mode, try not to allocate so much memory that Virtual Memory is used. This is because virtual memory uses the hard disk which has a slower access time than RAM, which may cause A/D Overrun problems at higher acquisition rates. If an A/D Overrun occurs, try lowering the number of points stored in memory, lowering the sample rate, or optimizing (even removing) other elements in the instrument such as Display (try using the Automatic Plot Technique) or Disk Out (try using a binary file format).

Status Messages

When the menu option is checked, run-time information about the element is sent to the Status Log. Under normal operation, this option should be turned off. If an error is encountered during operation of the instrument, the message will be sent to the Status Log regardless of the Status Messages setting.

Stop On Error

When the menu option is checked, any errors (underruns or overruns) encountered during operation of the instrument causes the instrument to stop immediately. When the menu option is not checked, the element continues operating in spite of the error.

Custom Commands

Some drivers add special menu commands to configure a unique hardware feature. Please refer to the documentation accompanying your hardware or any help files supplied by the hardware manufacturer.

Device Menu

1-8

Specifies the device used for this element. All installed hardware is listed by device number in this menu, with the active device indicated by a check mark next to the menu option.

Because Snap-Master supports multiple hardware devices running simultaneously, each piece of hardware is assigned a unique number. Hardware that has multiple functions, such as A/D, D/A, and Digital I/O, uses the same device number.

A menu caption of all dashes means there is no hardware specified for that device number.

Device Overview

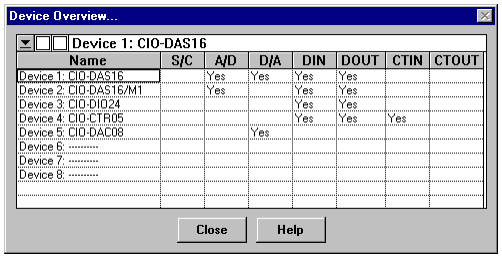


Figure 8-9 Device Overview

The Device Overview dialog specifies the I/O hardware for each device and shows which Snap-Master elements can be used for each device. Use the pull down list in the upper left corner of the dialog to change the I/O hardware for each device number. To disable a particular device, select the horizontal bar item from the end of the list.

The Snap-Master hardware I/O elements are abbreviated in the table as follows:

S/C	Signal Conditioning
A/D	Analog-to-Digital
D/A	Digital-to-Analog
DIN	Digital In
DOUT	Digital Out
CTIN	Counter-Timer In
CTOUT	Counter-Timer Out

Hardware Configuration

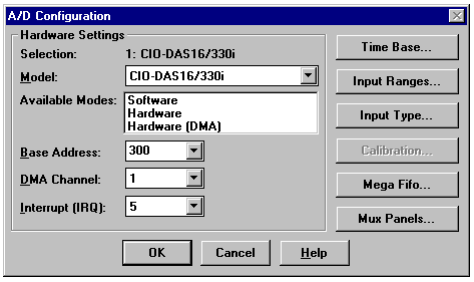


Figure 8-10 Device Configuration

For Snap-Master to properly communicate with your hardware, you must specify the correct Configuration for the selected device. For each of the settings available in the dialog, each piece of hardware must have its own unique settings. (The appearance of the Configuration dialog and the available options may differ for your hardware.)

Model	Specifies the hardware model for the current device.
Available Modes	Lists the available pacing modes for the hardware.
Base Address	Specifies the base address for the device (expressed as a hexadecimal value), if applicable.
DMA Channel	Specifies the DMA Channel for the hardware, if applicable.
Interrupt (IRQ)	Specifies the Interrupt Request channels for the hardware, if applicable.

8.3. Digital In

The Digital In element reads data from the digital input ports on your acquisition hardware. Because you can use multiple acquisition elements in an instrument, you can acquire both analog and digital data simultaneously. This hardware and all input devices must be properly configured in both hardware and software for proper data acquisition. Please refer to the hardware documentation for information on its features and its use with Snap-Master.

Digital In Settings

The Digital In Settings table (or dialog) operates in the same fashion as the A/D element. Pacing, Frame Length, Number of Frames, and the Channel List have the same meaning for the Digital In as the A/D element. The main difference between the elements is the type of data acquired, with the Digital In element acquiring digital data. For more information on the digital input capabilities of your hardware, please refer to the hardware's documentation.

8.4. Tutorial: Acquiring Analog Data

Before beginning this tutorial, please make sure that your hardware and software are correctly configured.

The pictures shown in this example used a 5 V, 1 Hz sine wave connected to Channel 0 of the A/D configured as Device 1. If you use a different input signal, you may see different results than those shown here. For simplicity, it is best to use a known signal as the input for this tutorial.

Building the Instrument

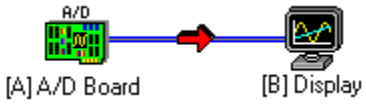


Figure 8-11 Instrument for Analog Acquisition Tutorial

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place an A/D element and a Display element in the instrument.

   Because you own the Data Acquisition Module, you must select which A/D element you wish to use. When you click once on the A/D element in the Toolbox, a pop up menu appears that lists which A/D drivers are currently installed. (The A/D Demo element is listed in this pop up menu because it uses the same icon.) The menu selection that has a check mark by it indicates which A/D board will be placed in the instrument when the icon is dragged to the instrument window. To change the selection, click on the desired driver.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the A/D element to the Display element.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as ANALOG.

Configuring the A/D Element

1. Open the A/D Settings by double clicking on the element.

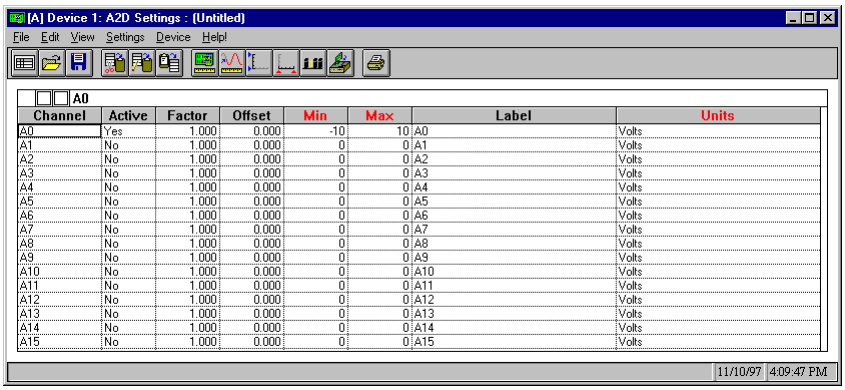

[A] Device 1: A2D Settings : (Untitled)
File Edit View Settings Device Help!
A0
Channel Active Factor Offset Min Max Label Units
A0 Yes 1.000 0.000 -10 10 A0 Volts
A1 No 1.000 0.000 0 0 A1 Volts
A2 No 1.000 0.000 0 0 A2 Volts
A3 No 1.000 0.000 0 0 A3 Volts
A4 No 1.000 0.000 0 0 A4 Volts
A5 No 1.000 0.000 0 0 A5 Volts
A6 No 1.000 0.000 0 0 A6 Volts
A7 No 1.000 0.000 0 0 A7 Volts
A8 No 1.000 0.000 0 0 A8 Volts
A9 No 1.000 0.000 0 0 A9 Volts
A10 No 1.000 0.000 0 0 A10 Volts
A11 No 1.000 0.000 0 0 A11 Volts
A12 No 1.000 0.000 0 0 A12 Volts
A13 No 1.000 0.000 0 0 A13 Volts
A14 No 1.000 0.000 0 0 A14 Volts
A15 No 1.000 0.000 0 0 A15 Volts
11/10/97 4:09:47 PM

Figure 8-12 A/D Settings

2. Press the button, or select the Settings menu, Frame Settings command.

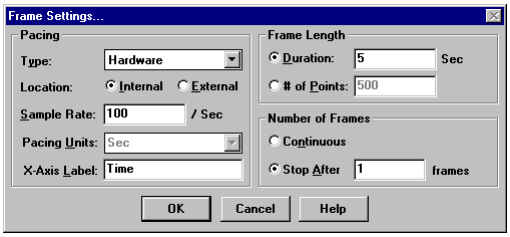


Figure 8-13 Frame Settings

3. Select the Hardware pacing type.

   If your hardware device does not support Hardware pacing, use Software pacing and set the Sample Rate in the next step to 10.

4. Set the Sample Rate to 100.

5. Change the Frame Length to a Duration of 5 seconds.

   The default selection for the Frame Length is the Number of Points option, so we need to specify the Duration as the measuring option. At this setting, each frame of data will contain five seconds, or 500 data points, of information.

6. Change the Number of Frames to Stop After 1 frame.

   The default selection for the Number of Frames group is for the instrument to run Continuously. Select the Stop After radio button. The default value for the Stop After field is 1, which is the setting we want.

7. Press the OK button to close the Frame Settings.

8. Make sure the first channel (or the channel you have your input wired to) has a "Yes" in the Active column.

9. Close the A/D Settings window with the File menu, Close command.

10. Save the instrument with the button or select the File menu, Save Instrument command.

Running the Instrument

1. Press the button or the Start! menu command.

If all is well, the Display window opens and begins plotting your input signal. If a signal appears but it is not what you expected, make sure you have the proper signal connection to the hardware. If the Status Log appears with an ERROR entry, follow the remedy listed. If all else fails, verify the hardware Configuration and your A/D Settings.

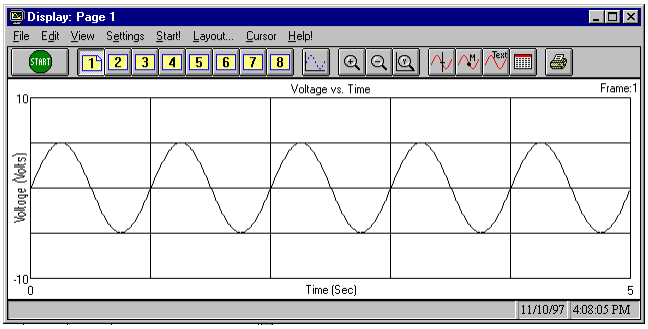


Figure 8-14 Acquiring a 1Hz, 5 V Sine Wave

8.5. Tutorial: Using Triggers to Start Acquisition

Using triggers, Snap-Master can define when to begin acquiring a frame of data. An example of this is using an input analog channel to define the starting point for data acquisition.

If your Trigger dialog does not look like the one shown in Figure 8-15, try to follow along - we will not set up a complicated trigger in this tutorial.

Setting Up A Trigger

1. Open the A/D Settings by double clicking on the A/D Board element icon.

2. Press the button or select the Settings menu, Trigger command.

   If the Trigger command is grayed out, then your A/D Board does not support any triggering in Snap-Master. In this case, you can skip ahead to the next tutorial.

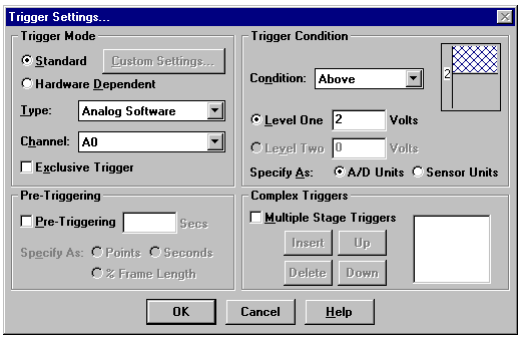


Figure 8-15 A/D Triggers Dialog Box

3. Select the Standard Mode, Analog Software Type.

   The default setting for the Trigger Type is Free Running, which means that the instrument will run without requiring any triggers. When you select Analog Software from the list, the other groups in the dialog are activated.

4. Select the Above Condition, and specify a Level One value of 2 Volts.

   This setting means that after the instrument is started, the A/D element waits for channel 0 to go above 2 volts. No data will appear in the Display until after the trigger condition is satisfied. Once channel 0 goes above 2 volts, the full 5 second acquisition frame is acquired and displayed.

5. Press the OK button to accept the changes to the Triggers dialog box.

6. Close the A/D Settings window with the File menu, Close command.

7. Save the instrument with the button or select the File menu, Save Instrument command.

Running the Instrument

1. Press the

button or the Start! menu command.

When you run the instrument this time, you will see the Display window wait until the A/D has received the correct trigger condition before it begins to plot data. (You may want to decrease the amplitude of your signal to below 2 volts to see the Display waiting, then increase the amplitude to satisfy the trigger condition.) If the Display does not receive the trigger condition, pressing the ESC key will manually trigger the instrument.

8.6. Tutorial: Acquiring From Multiple Devices

Up to this point, our instruments have operated with only one input element. Because Snap-Master has the capability to accommodate multiple input sources operating at different sampling rates, we can now look at acquiring data from multiple input elements in an instrument.

Depending on the configuration of your hardware, you can operate multiple input devices within a single instrument. The inputs can operate at different sampling rates and have different frame sizes. This is particularly useful when you want to acquire different types of data at both low and high speeds simultaneously.

This tutorial is written for two A/D devices, but will work with any two input elements such as an A/D and a Digital In, an A/D and an RS-232 In, two RS-232 In elements, etc. If you do not have multiple devices installed in your computer, you can use the A/D Demo as your second input element.

Building the Instrument

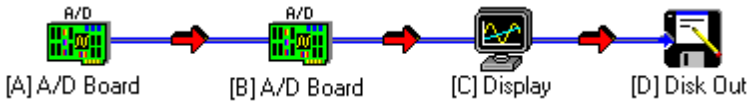


Figure 8-16 Instrument with Multiple A/D Devices

Figure 8-16 shows an instrument that contains two A/D devices, a Display element, and a Disk Out element. For this example, we will use different sampling rates and frame times for the A/D elements, overplot certain channels, and only save data from one A/D element.

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place two A/D elements (or the two input elements you want to use for this tutorial), a Display element, and a Disk Out element in the instrument.

   If you do not have a second A/D Board installed, you can select the A/D Demo element from the pop up menu.

   When the second board is placed in the instrument, it will address the same board as the first one. What we need to do is change the slot assignment for the board.

3. Open the second A/D Board Settings dialog box, select device 2 from the Device menu, then press the OK button.

   This changes the device number for the B element. Notice that the text underneath the element changes to reflect device number 2..

4. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

5. Connect the first A/D element to the second A/D element, the second A/D element to the Display element, and the Display element to the Disk Out element.

   Remember that data flows through elements, so the data from the first A/D element is still available to the Display and Disk Out elements.

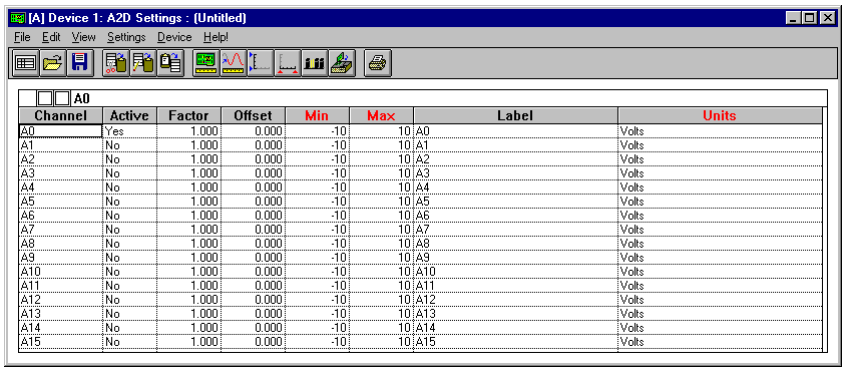
6. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

7. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as MULTBDS.

Configuring the Input Elements

If you are using input elements other than two A/D Boards, then apply the setup procedures to your specific elements.

1. Open the A/D Settings dialog box for element A.



Channel	Active	Factor	Offset	Min	Max	Label	Units
A0	Yes	1.000	0.000	-10	10	A0	Volts
A1	No	1.000	0.000	-10	10	A1	Volts
A2	No	1.000	0.000	-10	10	A2	Volts
A3	No	1.000	0.000	-10	10	A3	Volts
A4	No	1.000	0.000	-10	10	A4	Volts
A5	No	1.000	0.000	-10	10	A5	Volts
A6	No	1.000	0.000	-10	10	A6	Volts
A7	No	1.000	0.000	-10	10	A7	Volts
A8	No	1.000	0.000	-10	10	A8	Volts
A9	No	1.000	0.000	-10	10	A9	Volts
A10	No	1.000	0.000	-10	10	A10	Volts
A11	No	1.000	0.000	-10	10	A11	Volts
A12	No	1.000	0.000	-10	10	A12	Volts
A13	No	1.000	0.000	-10	10	A13	Volts
A14	No	1.000	0.000	-10	10	A14	Volts
A15	No	1.000	0.000	-10	10	A15	Volts

Figure 8-17 A/D Settings

2. Press the button, or select the Settings menu, Frame Settings command.

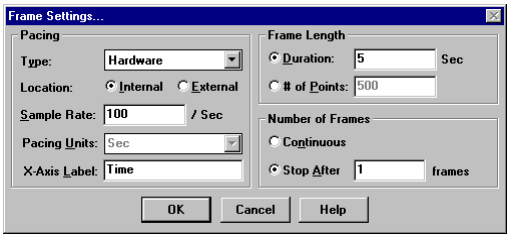


Figure 8-18 Frame Settings

3. Select the Hardware pacing type.

4. Set the Sample Rate to 100.

5. Change the Frame Length to a Duration of 5 seconds.

6. Change the Number of Frames to Stop After 1 frame.

7. Press the OK button to close the Frame Settings.

8. Make sure the first channel (or the channel you have your input wired to) has a "Yes" in the Active column.

9. Close the A/D Settings window with the File menu, Close command.

For the second A/D board, we will use different settings for the sample rate, frame length, and channels acquired.

10. Open the A/D Settings for element B.

11. Select a different Device than element A from the Device menu.

If you need to configure the second device, select the Device menu, Device Overview command.

12. Press the button, or select the Settings menu, Frame Settings command.

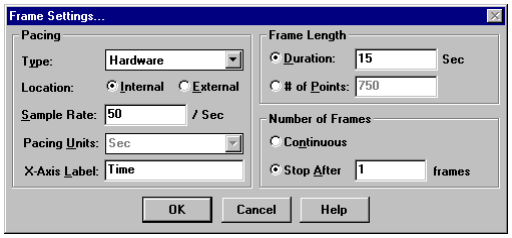


Figure 8-19 Frame Settings for Element B

13. Select the Hardware pacing type.

14. Set the Sample Rate to 50.

15. Change the Frame Length to a Duration of 15 seconds.

16. Change the Number of Frames to Stop After 1 frame.

17. Press the OK button to close the Frame Settings.

18. Make sure the first channel (or the channel you have your input wired to) has a "Yes" in the Active column.

19. Close the A/D Settings window with the File menu, Close command.

20. Save the instrument with the button or select the File menu, Save Instrument command.

Saving Data From Only One Channel

1. Open the Disk Out Settings by double clicking on the Disk Out element.

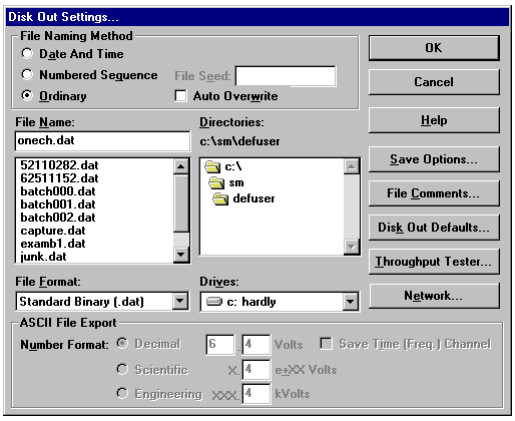


Figure 8-20 Disk Out Settings

2. Save the data file using the Ordinary naming method, and set the File Name to ONECH.

3. Press the Save Options button.

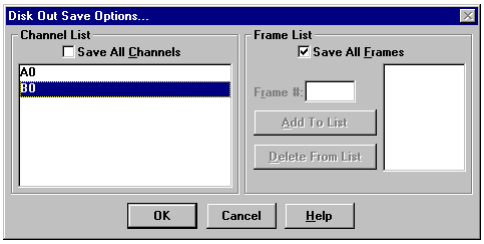


Figure 8-21 Disk Out Save Options

4. Turn off the Save All Channels check box.

   The Save All Channels check box automatically selects all available channels for storage to disk. By turning the check box off, you can write specific channels to disk. Disk Out only saves data from the channels that are highlighted in the channel list.

5. Highlight the B0 channel in the Channel List.

6. Press the OK button to close the Save Options dialog, then press the OK button to close the Disk Out Settings dialog box.

7. Save the instrument with the button or select the File menu, Save Instrument command.

Running The Instrument

1. Press the

button or the Start! menu command.

If your hardware is configured correctly, then the data should appear on screen and the data written to disk. If the Status Log appears with an ERROR entry, follow the remedy listed. If all else fails, verify the hardware Configuration and your A/D Settings.

8.7. Tutorial: Acquiring Digital Data

Acquiring data with the Digital In element uses the same steps as acquiring using an A/D element. Let's review the steps again, this time using a Digital In element.

Building the Instrument

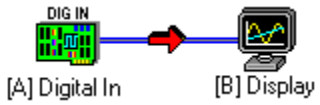


Figure 8-22 Instrument for Digital Acquisition Tutorial

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place a Digital In element and a Display element in the instrument.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the Digital In element to the Display element.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as DIGIN.

Configuring the Digital In Element

1. Open the Digital In by double clicking on the element.

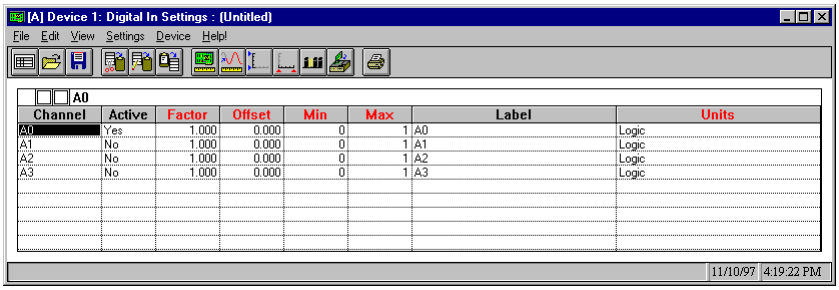

[A] Device 1: Digital In Settings : (Untitled)
File Edit View Settings Device Help!
A0
Channel Active Factor Offset Min Max Label Units
A0 Yes 1.000 0.000 0 1 A0 Logic
A1 No 1.000 0.000 0 1 A1 Logic
A2 No 1.000 0.000 0 1 A2 Logic
A3 No 1.000 0.000 0 1 A3 Logic
11/10/97 4:19:22 PM

Figure 8-23 Digital In Settings

2. Press the button, or select the Settings menu, Frame Settings command.

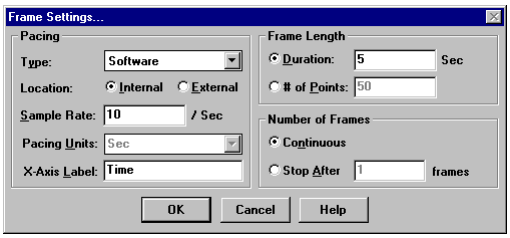


Figure 8-24 Frame Settings

4. Set the Sample Rate to 10.

5. Change the Frame Length to a Duration of 5 seconds.

6. Press the OK button to close the Frame Settings.

7. Make sure the first channel (or the channel you have your input wired to) has a "Yes" in the Active column.

8. Close the Digital Settings window with the File menu, Close command.

9. Save the instrument with the button or select the File menu, Save Instrument command.

Running the Instrument

1. Press the

button or the Start! menu command.

If all is well, the Display window opens and begins plotting your input signal. If the Status Log appears with an ERROR entry, follow the remedy listed. If all else fails, verify the hardware Configuration and your A/D Settings.

(The plot shown below has the Major Divisions in both the X-axis and Y-axis set to "None" for clarity.)

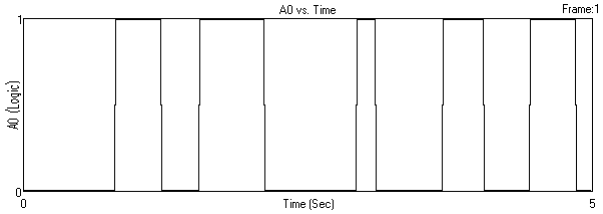


Figure 8-25 Acquiring Digital Data

Chapter 9. Counter Timer

9.1. Counter Timer Input 9-2
9.2. Tutorial: Measuring Pulse Counts 9-6
9.3. Tutorial: Frequency Measurements 9-10
9.4. Overview Of The 9513 9-14

The Counter Timer element performs various counting and timing functions using digital input signals. Snap-Master addresses hardware that uses a 9513 chip. The Counter Timer is useful for measuring a number of events, measuring the frequency of an input signal, measuring the period of a signal, as well as a variety of other uses.

When using the Counter Timer element, you will spend most of your time in the 9513 Configuration dialog. This is where each channel of the 9513 is configured for different functionality. This dialog is accessed through the Configuration dialog because most changes in a channel's function require rewiring the inputs to the Counter Timer hardware.

Special Wiring Instructions

In order to read data from Counter Timer hardware in Snap-Master, the hardware needs a dedicated pacing clock going in to the Interrupt Input (INT IN) pin. In addition, the Interrupt Enable pin must be connected to Ground (GND) to activate the INT IN pin.

For many applications, one of the counters on the hardware can be used as the master pacing clock. Usually, Counter 5 is used as the pacer in Snap-Master. In the 9513 Configuration dialog, this channel is designated as an Internal Pacer. You MUST physically connect the Output pin of the Internal Pacer counter to the Interrupt Input pin.

For example, if Counter 5 is used as the pacer, the following connections must be made (the diagram assumes the pin outs of CTM-05 compatible Counter Timer hardware - please refer to the hardware documentation for pin out information):

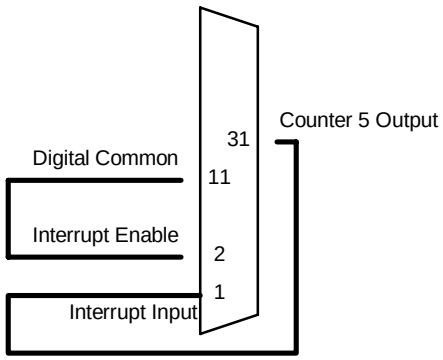


Figure 9-1 CTM-05 Compatible Connections for Internal Pacer Using Counter 5

9.1. Counter Timer Input

The Counter Timer Input element has the same user interface as the A/D and Digital In elements. The main dialog used for the Counter Timer element is the 9513 Setup dialog, which is opened from the Device menu, Hardware Settings dialog.

9513 Setup

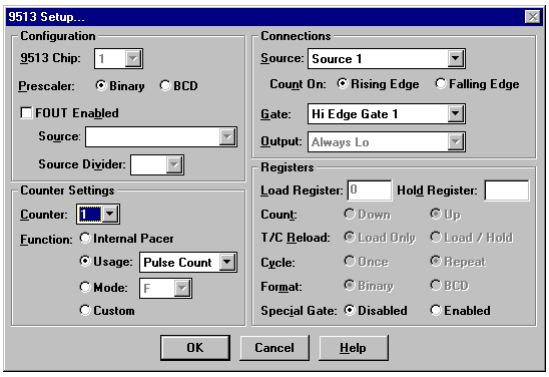


Figure 9-2 9513 Setup

The 9513 Setup dialog is used to set up exactly how each channel of the available 9513 chips is configured. To open this dialog, select the Device menu, Hardware Settings command and press the 9513 Setup button.

Because a change in these settings usually requires a change in the hard wiring configuration, the 9513 settings are NOT stored in each instrument file - they are stored in the hardware configuration file. If you want to keep multiple 9513 configurations without setting them up by hand each time, you will need to save backup copies of the *.CNF files (the hardware configuration files) located in the DEFUSER directory.

Configuration

9513 Chip — Selects which 9513 chip is being set up in the dialog. Some Counter Timer hardware has more than one 9513 chip, which increases the number of available counters.

Prescaler — The Prescaler is a four-stage frequency divider (called F1 through F5) fed by a master clock located on the Counter Timer hardware (for CTM-05 compatibles, the clock frequency is 1 MHz). The divider is either in **Binary** (divides each stage of the frequency divider by a factor of sixteen) or **BCD** (divides each stage of the frequency divider by a factor of ten).

FOUT Enabled — FOUT is a special pin output of the Counter Timer hardware. When the FOUT Enabled check box is turned on, select an available **Source** along with a **Source Divider**. When the FOUT Enabled check box is turned off, the output at the FOUT pins is TTL low.

Source — The available Source signals are the frequency dividers F1 through F5, and the Source and Gate inputs of the available counters. Note that the current frequency of F1 through F5 depends on both the Prescaler selection as well as the Source Divider. Each frequency divider's current frequency (based on the Source Divider setting) is displayed directly in the Source list so no further math is required.

Source Divider — A 4-bit number between 1 and 16 which subdivides the Source.

Counter Settings

Counter — Selects the counter number being edited in the dialog.

Function — **Internal Pacer** designates the channel as the counter used to generate the inputs based on the Sample rate. Only one counter needs to be defined as an Internal Pacer. Remember to connect the output of this counter to the INT IN pin, and connect the Interrupt Enable to ground.

Several common uses are listed with the **Usage** radio button. When a Usage type is selected, predefined settings are filled in the Connections and Register groups. Certain controls are also disabled, to prevent you from drastically changing the function of the counter.

For users who are familiar with the 9513, the **Mode** radio button lets you select one of the modes as defined by the manufacturer.

Custom enables all settings in the Connections and Registers groups for complete control over how the 9513. When Custom is selected, the counter output has units of "Ticks."

The common Usages are as follows:

Usage	Output Units	Description
Pacer		Divides F1-F5 by initial count, pulses out each time count decrements to 0. Not intended for input channel. (9513 Mode D)
Frequency	(Hz)	Counts the channel's source pulses. Holds count and restarts at initial count each time Gate pulses. Use same pulse connected to INT input for Gate input. If the input frequency is too large to measure, the output of the counter is 0. (9513 Mode O)
One-Shot		Generates a single pulse after channel is started, delayed by initial count. Not intended for input channel. (9513 Mode A)
Pulse Count	(Ticks)	Counts channel's source continuously without reloading initial count. (9513 Mode F)

Period	(Sec)	Measures time duration of channel's gate input edges. If no internal pacer, connect Gate input to INT input. Otherwise, only one pulse will be measured per sample interval. If the period is too long (so a T/C occurs before a Gate edge), the output is 0. (9513 Mode O)
Rate Gen		Divides F1-F5 source by initial count, pulses out each time count decrements to 0. Not intended for input channel. (9513 Mode D)
Rate Gen (Gated)		Same as Rate Gen, except uses a level Gate to hold off source. (9513 Mode E)

Connections

The Connections group defines the actual inputs and outputs of the 9513 counter. A 9513 counter has the following inputs and outputs:

Source — Defines the signal used to determine when to count.

T/C n-1 uses the Terminal Count event on the previous counter, as listed. The first counter on the 9513 wraps around to the last counter on the same 9513.

Source Inputs use the signal connected to the selected Source input on the termination panel.

Gate Inputs use the signal connected to the selected Gate input on the termination panel.

F1-F5 are fixed-frequencies set by the Prescaler format.

Count On — Determines the edge direction of the Source signal when a count occurs. The edge is specified as either a **Rising Edge** (low to high) or **Falling Edge** (high to low).

Gate

Sets the gating condition which determines how the counting function occurs. When a Gate condition is defined, counting occurs only when the condition is satisfied.

None means there is no gating.

High T/C n-1 means the gate condition is satisfied when the Terminal Count event on the previous counter is High. The first counter wraps around to the last counter on the same 9513.

Hi Level Gate means the gate condition is satisfied when the signal connected to the selected Gate input is High. Available for either the previous counter, the current counter, or the next counter.

Lo Level Gate n means the gate condition is satisfied when the signal connected to the current Gate input is Low.

Hi Edge Gate n means the gate condition is satisfied when the signal connected to the current Gate input changes from Low to High.

Lo Edge Gate n means the gate condition is satisfied when the signal connected to the current Gate input changes from High to Low.

Also, the Special Gate setting in the Registers group determines if the Gate is used to retrigger the count by resetting the counter with the value from the appropriate register.

Output

Defines the signal sent to the output of the counter.

Always Hi means the output is a constant TTL high.

Always Lo means the output is a constant TTL low.

Hi T/C Pulse means the output is normally low, and changes to high when the Terminal Count event occurs.

Lo T/C Pulse means the output is normally high, and changes to low when the Terminal Count event occurs.

T/C Toggle means the output inverts (high to low, or low to high) when each Terminal Count event occurs.

Registers

Load Register	Register for a 16-bit value (0 to 65535) used to set the initial count for the counter on a Terminal Count.
Hold Register	Register used by Snap-Master to read the current value of the counter. Also used for certain modes to load the counter with a value other than the Load Register. Also a 16-bit value.
Count	Determines if the counter counts **Up** or **Down** on a Source edge). A Terminal Count (T/C) occurs when the Counter reaches 0. In the Up case, 0 is the next value after 65535.
T/C Reload	Determines which register is used to reset the counter. **Load Only** uses the value of the Load Register, and is the most commonly used option. **Load / Hold** toggles between the Load and Hold registers, and is used mostly for frequency shift keying and variable duty cycle rate generation.
Cycle	Determines what happens when the counter is reset. **Once** lets the counter reach Terminal Count (T/C) once, then disables itself until the next data frame. **Repeat** resets the counter to the appropriate register after each T/C and restarts the counting function.
Format	Determines the counting method for the counter as either **Binary** (each 4-bit group counts from 0 to 15, where the groups are either the lower or upper half of the 8-bit word) or **BCD** (each 4-bit group counts from 0 to 9). Binary is the option used in most cases.
Special Gate	When **Enabled**, the Gate input interacts with the Reload and Cycle settings depending on the mode (9513 Modes N, O, Q, R, S, V, and X). This sets up a hardware latch that provides extremely accurate readings (<1µS error). When **Disabled**, a software latch is used to respond to an interrupt pulse. There is an indeterminate time delay between the time an interrupt occurs and the time when the count value is read, which is on the order of a few mS. If this delay is negligible, then Software latching is recommended.

9.2. Tutorial: Measuring Pulse Counts

This tutorial counts the number of incoming pulses using Counter Timer hardware based on the 9513 chip. In this example, the Counter Timer input element is used to sample the incoming pulses as a function of some external digital pulse event, which is sometimes associated with some external physical unit, such as degrees or revolutions.

Building the Instrument

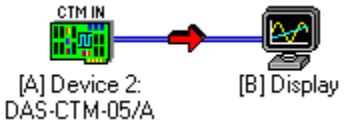


Figure 9-3 Instrument for Counter Timer Pulse Counts Tutorial

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place the Counter Timer and Display elements in the instrument.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the Counter Timer element to the Display element.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as PULSE.

Configuring A Counter For Pulse Counting

1. Open the Counter Timer Settings by double clicking on the element.

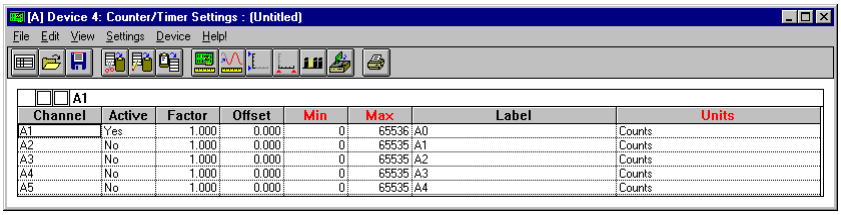

[A] Device 4: Counter/Timer Settings : (Untitled)
File Edit View Settings Device Help!
A1
Channel Active Factor Offset Min Max Label Units
A1 Yes 1.000 0.000 0 65536 A0 Counts
A2 No 1.000 0.000 0 65535 A1 Counts
A3 No 1.000 0.000 0 65535 A2 Counts
A4 No 1.000 0.000 0 65535 A3 Counts
A5 No 1.000 0.000 0 65535 A4 Counts

Figure 9-4 A/D Settings

2. Press the button, or select the Settings menu, Frame Settings command.

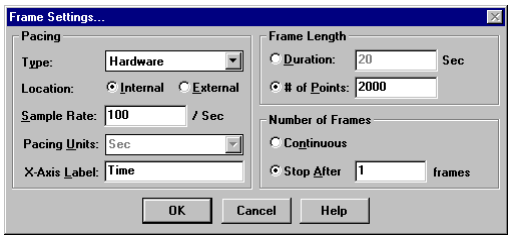


Figure 9-5 Frame Settings

3. Select the Hardware pacing type.

   If your hardware device does not support Hardware pacing, use Software pacing and set the Sample Rate in the next step to 10.

4. Set the Sample Rate to 100.

5. Change the Number of Frames to Stop After 1 frame.

   The default selection for the Number of Frames group is for the instrument to run Continuously. Select the Stop After radio button. The default value for the Stop After field is 1, which is the setting we want.

6. Press the OK button to close the Frame Settings.

7. Make sure the first channel has a "Yes" in the Active column.

8. Press the button, or select the Device menu, Hardware Configuration command.

9. Press the 9513 Setup button.

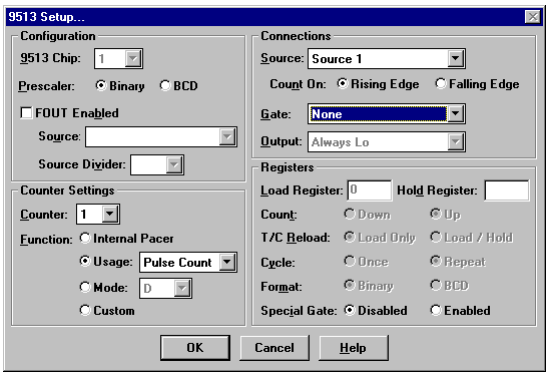


Figure 9-6 9513 Settings for Pulse Count

10. Select Counter 1 from the Counter list.

11. Select the Usage radio button, then select Pulse Count from the Usage list.

    For Pulse Counting, the counter measures the rising edge of TTL pulses on the Source 1 input (which is the input pin to counter 1 on the termination panel) each time the INT IN pin receives a rising TTL edge. The counter counts up from 0 to 65535, then it Repeats the counting until the end of the frame.

12. Set the Gate to None.

    We do not need a Gate signal, so set that to None. The Mode changes from F to D because we are not using a Gate signal. Notice that there are few settings we can change when the Usage is defined as Pulse Count. This is to prevent you from drastically changing the functionality of the Usage. Of course, you can set the Usage to Custom if you want to control all of the settings.

    For this example, we are assuming that you do not need the most recent value of the pulse count on each interrupt. In applications where you want highly accurate readings, set the Special Gate to Enabled and connect the Pacing channel (which we cover next) to the Gate of the counter. This way, each Gate edge transfers the contents of the counter to the Hold Register and Snap-Master reads the value.

Configuring A Counter As An Internal Pacer

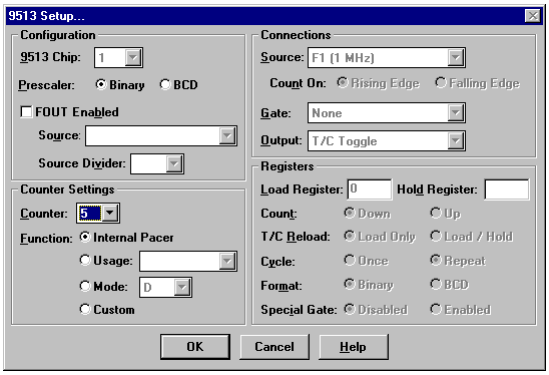


Figure 9-7 9513 Settings for Internal Pacer

In order to read the values from Counter 1, we need a pacer to define when a hardware interrupt occurs. For this tutorial, we will use Counter 5 as an Internal Pacer.

1. Select Counter 5 from the Counter list.

2. Select the Internal Pacer radio button.

   Once a counter is specified as an Internal Pacer, no other settings need to be changed. The value of the Load Register is calculated automatically from the Sample Rate defined in the Counter Timer Settings dialog.

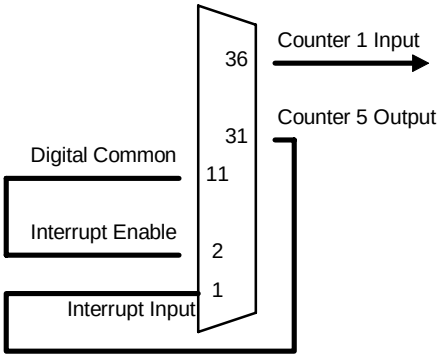
3. Close the 9513 Settings dialog by pressing the OK button.

4. Press the OK button to close the Configuration dialog.

5. Close the Counter Timer Settings window with the File menu, Close command.

6. Save the instrument with the button or select the File menu, Save Instrument command.

Signal Connections



For our connections, the Output pin of Counter 5 must be connected to the Interrupt Input pin, and the Interrupt Enable signal must be tied to ground so the pacer pulses generate a hardware interrupt and cause Snap-Master to sample the data. Our input signal for Counter 1 is connected to the Source 1 pin. (Pin numbers shown for CTM-05 compatible hardware.)

Running The Instrument

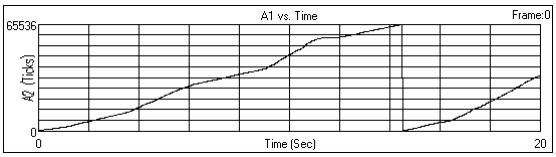


Figure 9-8 Results of the Pulse Count Tutorial

When you run the instrument, a waveform of Ticks vs. Time appears in the display (this input signal is a TTL square wave which was varied from 900 to 4500 Hz). Note that the count wraps around from 65535 to 0 (because the count range is 65536 and the Cycle is set to Repeat). If you do not see any data, make sure you have an Internal Pacer defined and the correct physical connections are made to generate a hardware interrupt.

9.3. Tutorial: Frequency Measurements

This example builds off our setup in the last tutorial. In addition to the Pulse Count measurement, we will measure the frequency of the same incoming signal.

Configuring A Counter To Measure Frequency

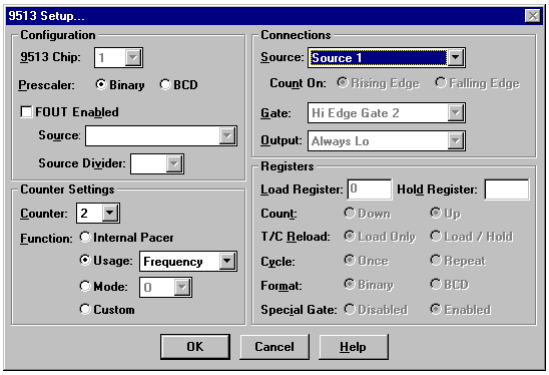


Figure 9-9 9513 Settings for Frequency Measurement

1. Open the Counter Timer Settings by double clicking on the element.

2. Set the Active column to "Yes" for channel A2.

3. Press the button, or select the Device menu, Hardware Configuration command.

4. Press the 9513 Setup button.

5. Select Counter 2 from the Counter list.

6. Select the Usage radio button, then select Frequency from the Usage list.

   To measure the frequency of an input channel, the counter counts the number of pulses which occur between successive rising edges on the Gate input. This configuration assumes that the Gate input is connected to the same pulse source as the INT IN lead, which is our Pacing clock from counter 5.

Each time the INT IN pulse source has a rising edge, the counter value is transferred to the Hold Register, which Snap-Master reads. This value is then scaled by the Sample Rate in the Counter Timer Settings dialog to produce a frequency value. In this example we are sampling at 100 samples per second, so the counter value is multiplied by 100.

Note that the best frequency resolution that you can measure is the same as the Sample Rate. In this example, we can measure no finer an increment in frequency than 100 Hz.

7. Select Source 1 from the Source list.

Since we already have the input signal coming in on Source 1, select it as the input for Counter 2. This means we do not have to make another physical connection for the input channel (we still do for the Gate of Counter 2).

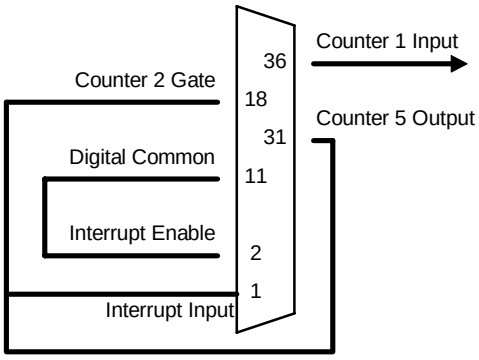
8. Close the 9513 Settings dialog by pressing the OK button.

9. Press the OK button to close the Configuration dialog.

10. Close the Counter Timer Settings window with the File menu, Close command.

11. Switch to the Snap-Master window and save the instrument with the button or with the File menu, Save command.

Signal Connections



The same connections from the previous section are used, with one addition. The Counter 2 Gate must be connected to the Counter 5 Output for the frequency measurement. (Pin numbers shown for CTM-05 compatible hardware.)

Running The Instrument

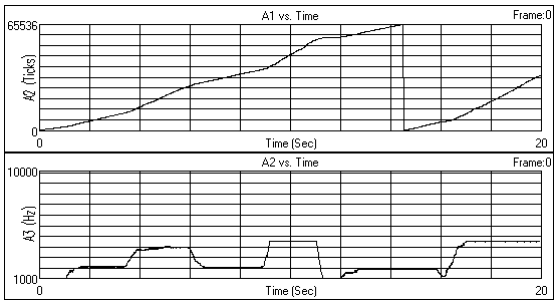


Figure 9-10 Results of the Pulse Count Tutorial

When you run the instrument, you should see the number of counts increase as the frequency increases, and vice versa. As in the previous tutorial, this signal is a TTL square wave which was varied from 900 to 4500 Hz.

Alternate Frequency Measurement Method

There are at least two different ways to measure frequency with Counter Timer hardware in Snap-Master. This tutorial illustrates the simplest method, which essentially measures the number of interrupts (generated by the Internal Pacer) between input signal edges. The count is then scaled by the Sample Rate to define the frequency of the signal.

The drawback to this method is the relatively low resolution of the output. Frequency resolution is a direct function of the sample rate because the counter is gated by the same signal that determines when to retrieve the value of the counter. Low sample rates will have higher resolution than high sample rates, because the counter is allowed to read more Source edges before the Gate resets the counter. At 1000 samples per second, the resolution is ±1000 Hz, which means you can only resolve in multiples of 1000 Hz: 1000 Hz, 2000 Hz, etc. At a sample rate of 10 Hz, the resolution is 10 Hz, so you can resolve all multiples of 10: 10, 20, ..., 1000, 1010, etc.

An alternate method of measuring frequency requires using the output of an additional counter to gate the frequency channel instead of the "Internal Pacer" channel. The advantage to this method is the resolution of the frequency measurement is independent of the sampling rate. As with the first method, an Internal Pacer counter is required and its output is tied to the Interrupt Input. In this case, the output of the Pacer counter is not tied to the gate of the frequency measurement counter.

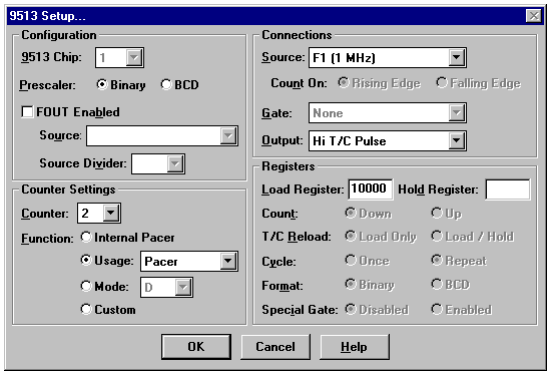


Figure 9-11 Configuring a Pacer Channel

The additional counter (assume counter 2) should be configured as a Pacer by setting the Usage to "Pacer". Set the Load Register for counter 2 to 10000.

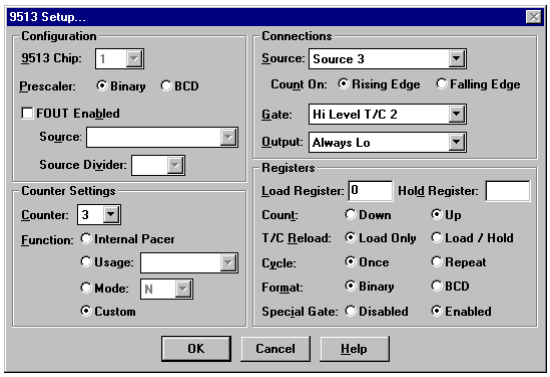
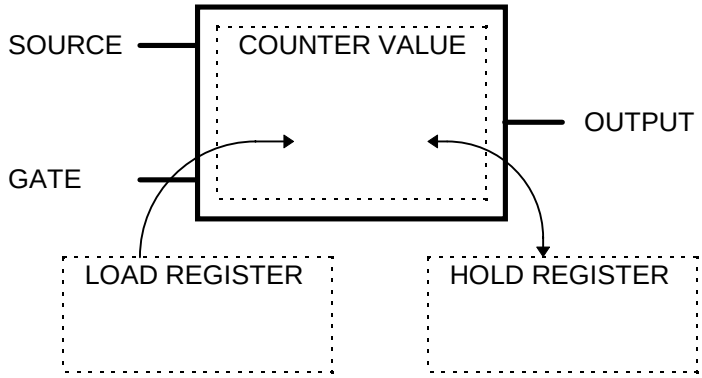


Figure 9-12 Configuring a Custom Frequency Measurement

The counter used to measure frequency (assume counter 3) should have its Usage set to Frequency, then to Custom. By selecting Frequency before Custom, the 9513 Setup dialog automatically sets the parameters for making a frequency measurement, and the Custom usage allows you to edit all parameters. By changing the Gate input to Hi Level T/C 2, the Gate now is active when a Terminal Count occurs on counter 2.

In the Counter Timer Settings dialog, select the Custom channel (channel 3) from the Channel List. The data collected from that channel is in units of Hertz, but the value is off by a factor of 100. This is a result of the input clock to the Pacer channel and the Load Register value (in this case F1 divided by the Load Register gives us the factor). You can compensate for the factor by multiplying the value by 100 using either the Analysis or Sensor elements.

9.4. Overview Of The 9513



9-13 Counter Inputs, Outputs, and Registers

The Am9513A chip from Advanced Micro Devices, Inc. provides a variety of counting, sequencing, and timing functions. Most dedicated Counter Timer hardware uses this chip to perform such tasks as frequency synthesis, pulse generation, event counting, duty cycle measurements, and many others.

Because the Counter Timer hardware is heavily influenced by the operation of the 9513, this section presents a brief overview of the 9513 and its nomenclature. For a more comprehensive discussion of the chip's capabilities, we encourage the user to refer to the Am9513A System Timing Controller description, available from Advanced Micro Devices, Inc. (800-538-8450) or an AMD dealer.

Source, Gate, and Output

Each counter has a Source, Gate, and an Output signal as indicated by the thick lines in Figure 9-13. These signals are available for each counter at the termination panel for the Counter Timer hardware.

The Source input is the signal used to determine when to perform a counting action. The count occurs on either a rising or falling edge. There are sixteen different signals that can be used as the Source: the five SOURCE inputs from the termination panel, the five GATE inputs from the termination panel, the five internal frequencies F1 through F5, and the Terminal Count (T/C) from the previous counter (counter 5 reads the T/C from counter 4, counter 4 reads the T/C from counter 3, and so on with counter 1 wrapping around to read the T/C from counter 5). For the T/C from the previous counter and the fixed frequency inputs F1 through F5, you do not need to make a physical connection at the termination panel.

The Gate input controls when counting of the Source input occurs. When the Gate condition is satisfied, the counter proceeds as defined by the Source input. Gating options include no gate (counting proceeds unconditionally), a High or Low state of the counter's Gate input, a High-to-Low or Low-To-High transition of the counter's Gate input, a High state of the previous or next counter's Gate input (for example, the Gate for counter 4 looks for a High state on the Gate input of counter 3 or counter 5), or a Terminal Count (T/C) event on the previous counter. For the T/C from the previous counter or the Gate inputs of other counters, you do not need to make a physical connection at the termination panel.

The Output generates a digital High or Low based on the Terminal Count (T/C) of the counter. On a T/C event of the counter, the Output can produce a High Pulse where the Output changes from its normal Low to High on a T/C for one count, a Low Pulse where the Output changes from its normal High to Low on a T/C for one count, or a Toggle where the Output inverts between High and Low at each T/C. If the Output is not used elsewhere, it can be set to a continuous High or Low state.

Load and Hold Registers

The 9513 has two configurable registers per channel to hold 16-bit data values (from 0 to 65535): the Load register and the Hold register. This Load register sets the initial count of the counter, and a Terminal Count (T/C) can be used to reset the value of the counter to either the Load or Hold register value. For most applications, the Hold register is only used to transfer the current data value from the counter to Snap-Master while the counter is accumulating.

Terminal Count (T/C)

A Terminal Count (T/C) event occurs when the counter value reaches 0. The T/C is used to reload the counter with Load or Hold register value, or to control other counters.

Modes

The 9513 has a number of predefined "modes" to describe the counter function. These modes define common uses for the various input and output signals, as well as the counting methods and other options. While most applications are satisfied with one of the modes, they do not cover all possible combinations. A brief description of each mode and its use in Snap-Master is included below.

Mode A **Software-Triggered Strobe with No Hardware Gating**

At the beginning of each frame, the Load register sets the initial value of the counter. On each Source edge, the counter accumulates its value. When the counter value reaches 0, a T/C is generated and the counter value is reset to the Load register value. If a new frame starts before a T/C is reached, the counter is reset to the Load register value. After the T/C, the count does not begin until the counter is rearmed when a new frame begins.

Mode B **Software-Triggered Strobe with Level Gating**

This mode performs the same counting operation as Mode A, except that the Source edge is only counted when the Gate condition is met.

Mode C **Hardware-Triggered Strobe**

This mode performs the same counting operation as Mode A, except that the Source edge is only counted when a Gate edge occurs. This differs from Mode B, where the Gate condition must be satisfied for each Source edge. Mode C requires only one Gate edge to begin counting.

Mode D **Rate Generator with No Hardware Gating**

At the beginning of each frame, the Load register sets the initial value of the counter. The counter repetitively counts to T/C and reloads the Load register value. As a result, the Load register value determines the time between T/Cs. When the Output is set to the T/C Toggled signal, a square wave is generated.

Mode E **Rate Generator with Level Gating**

This mode performs the same function as Mode D, except that the counter only counts the Source edges which occur while the Gate condition is satisfied.

Mode F **Non-Retriggerable One Shot**

At the beginning of each frame, the Load register sets the initial value of the counter. Counting is enabled on a Gate edge. When the counter reaches T/C, the counter value is reset to the Load register value. Counting does not begin until a new Gate edge condition is satisfied. This differs from Mode C, which can only be triggered once per frame.

Mode G **Software-Triggered Delayed Pulse One Shot (Output Only)**

At the beginning of each frame, the Load register sets the initial value of the counter, then begins counting. When the counter reaches T/C, the counter value is reset to the Hold register value, and the count restarts from the new value. When the counter reaches the second T/C, the counter reloads the Load register value and disarms itself until it is rearmed with a new frame.

A software-triggered delayed pulse one shot is obtained by setting the Output to the T/C Toggled signal. The Load register value determines the delay between when the counter is armed and the output pulse starts. The Hold register value determines the duration of the pulse.

Mode H **Software-Triggered Delayed Pulse One Shot with Hardware Gating (Output Only)**

This mode performs the same function as Mode G, except that the count only occurs when the Gate condition is satisfied. This allows the Gate input to extend both the initial output delay and the pulse width.

Mode I **Hardware-Triggered Delayed Pulse Strobe (Output Only)**

This mode performs the same function as Mode G, except that the count begins after the Gate condition is satisfied. After the second T/C, the counter waits to be rearmed and a Gate edge occurs to begin counting. This differs from Mode H where the Gate is used to stop and start the counter.

Mode J **Variable Duty Cycle Rate Generator with No Hardware Gating (Output Only)**

At the beginning of each frame, the Load register sets the initial value of the counter, then begins counting. The counter accumulates until it reaches the first T/C, when it reloads the counter with the Hold register value, Counting then proceeds to the second T/C, when the Load register value is used to reset the counter value. The counting repeats in this fashion until a new frame, when the counter value is reset by the Load register. By setting the Output to the T/C Toggled signal, the Load and Hold values determine the output duty cycle. A high frequency clock on the Source gives high resolution.

Mode K **Variable Duty Cycle Rate Generator with Level Gating (Output Only)**

This mode performs the same function as Mode J, except that counting only occurs on each Source edge where the Gate condition is satisfied. This allows the Gate input to modulate the duty cycle, because it affects both the High and Low portions of the output waveform.

Mode L **Variable Duty Cycle Rate Generator with Level Gating (Output Only)**

This mode performs the same function as Mode J, except that counting begins after the Gate condition is satisfied. The count proceeds until the second T/C, when the counter reloads the Load register value and waits for the next Gate condition before restarting. This differs from Mode K where the Gate is used to affect the duration of the High and Low times.

Mode N **Software-Triggered Strobe with Level Gating and Hardware Retriggering**

At the beginning of each frame, the Load register sets the initial value of the counter. The count accumulates on a Source edge only when the Gate condition is satisfied. Upon reaching T/C, the counter reloads the Load register value and disarms itself until the next frame begins. If a Gate edge occurs (so the condition is not satisfied) before T/C is reached, the next Gate edge (where the condition is satisfied) causes the counter to be reloaded from the Load register on the next Source edge. Counting resumes on the second Source edge while the Gate condition is still satisfied. Each Gate edge causes the counter value to be transferred to the Hold register.

Mode O **Software-Triggered Strobe with Edge Gating and Hardware Retriggering**

This mode performs the same function as Mode N, except that counting only occurs after the Gate condition is satisfied and the Gate level does not modulate the counting function. All Source edges that occur after the Gate condition is satisfied are counted until the T/C is reached. After T/C, the counter reloads the Load value and waits for the next Gate edge. If a Gate edge occurs before T/C is reached, the next Source edge when the Gate condition is satisfied causes the counter to reload the Load register value and counting resumes on the second Source edge. Unlike Modes C, F, I, and L, the Gate input causes the counter to restart the count.

Mode Q **Rate Generator with Synchronization (Event Counter with Auto-Read/Reset)**

At the beginning of each frame, the Load register sets the initial value of the counter. The count accumulates on a Source edge only when the Gate condition is satisfied. Upon reaching T/C, the counter reloads the counter with the Load register value. If a Gate edge that satisfies the Gate condition occurs before reaching T/C, the contents of the counter are transferred to the Hold register and the next Source edge while the Gate condition is still satisfied transfers the Load register value to the counter. Counting resumes on the second Source edge after the retriggering Gate edge.

Mode R **Retriggerable One-Shot**

This mode performs the same function as Mode Q, except that the Gate edge only determines when to start counting. Upon reaching the T/C, the counter is reloaded with the Load register value. All Gate edges retrigger the process by moving the counter value to the Hold register, resetting the counter with the Load register value on the next Source edge, and accumulating on the second Source edge after retriggering. This differs from Mode Q, which uses the level rather than the edge of the Gate to determine when to count and reset the counter.

Mode S **Reload Source**

At the beginning of each frame, the value of the Gate determines if the initial value of the counter is set to the Load register or the Hold register. If the Gate is Low then the counter is set to the Load register value, and if the Gate is High then the counter is set to the Hold register value. The counter then accumulates to the first T/C and reloads the value as determined by the gate. Counting continues until the second T/C, after which the counter is disarmed until the next frame occurs.

Mode V **Frequency-Shift Keying**

This mode performs the same function as Mode S, except that the counter is reloaded after every T/C. Again, the Gate determines which register is loaded (Low = Load, High = Hold). Frequency shift keying is accomplished by setting the Output to the T/C Toggled signal. The frequency switching occurs by modulating the Gate.

At the beginning of each frame, the value of the Gate determines if the initial value of the counter is set to the Load register or the Hold register. If the Gate is Low then the counter is set to the Load register

Mode X **Hardware Save**

This mode is available only with Counter Timer hardware based on the Am9513A.

At the beginning of each frame, the value of the Load register is transferred to the counter. Counting begins on the first Gate edge where the Gate condition is satisfied. Each subsequent Gate edge causes the counter value to be transferred to the Hold register until T/C is reached. These Gate edges do not alter the counting function. After reaching T/C, the counter is reloaded with the Load register value, and counting begins on the next Source edge after the next Gate edge that satisfies the Gate condition.

Chapter 10. RS-232

10.1. RS-232 Settings 10-2
10.2. Tutorial: Writing Example RS-232 Strings 10-8

The RS-232 element provides an interface between Snap-Master and external equipment that communicates ASCII data over the serial ports of your computer. The communication can be either one-way where Snap-Master only reads incoming information from the equipment, or two-way so Snap-Master can send ASCII commands to set up the equipment.

Like the other acquisition element dialogs (such as the A/D element), the RS-232 element contains information about the equipment being controlled by Snap-Master. The Strings dialog contains information about how Snap-Master interprets the ASCII strings sent by the equipment, along with any strings used by the equipment for configuration. *These dialogs do not determine how the equipment actually operates, they only specify how Snap-Master communicates with the equipment.*

Answers To Commonly Asked Questions

- **How fast does the RS-232 element sample data?**

  The rate at which the RS-232 element can read data is dependent upon many factors including the type of PC, the baud rate, the instrument and other factors. Many times an experiment must be performed to determine the performance with specific hardware. Rates of three samples per second per channel (while acquiring 32 channels) have been achieved with the IOtech Tempscan 1000.

- **Can I control more than one RS-232 instrument at the same time?**

  The RS-232 element supports up to four pieces of serial equipment operating simultaneously.

- **Does the RS-232 element support RS-485?**

  The RS-232 element can support RS-485 the same way RS-232 specific equipment is supported. However, Multi-Drop is not currently supported.

- **If my RS-232 instrument doesn't support handshaking, do I have to use it?**

  The RS-232 element does **not** require software or hardware handshaking.

- **My instrument supports termination, but not delimiters. How does the RS-232 element support this hardware?**

  Even if your instrument does not explicitly support delimiters, Snap-Master may be able to support it if there is some constant character in the data string that can be specified as a delimiter. For example, the following data string has the format of "time/date data" without specific delimiters:

  8/15/21/1/1/93 1.3 Volts

The year "93" could be specified as a delimiter because it does not change from reading to reading. The string will be broken into two parts, "8/15/21/1/1/93" and "1.3 Volts" the 1.3 will be read out of the second token.

- **Does Snap-Master support multiport RS-232 cards?**

  Multiport cards are not currently supported.

- **Can the RS-232 element read Hexadecimal or binary data?**

  No, the RS-232 element can only read numbers, letters and some control characters. Only numbers (integers or floating point numbers) can be interpreted as data.

- **In order to read data from my RS-232 equipment, I first need to send one string, then, based on the response, I need to send a second string to retrieve the data. Can I do this?**

  The RS-232 element does not currently support conditional responses, or sending commands based on previous responses.

10.1. RS-232 Settings

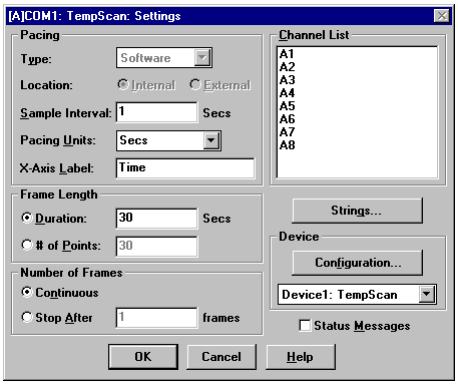


Figure 10-1 RS-232 Settings

The Settings dialog informs Snap-Master how the external RS-232 equipment is sending data over the serial port, and operates the same way the A/D Settings dialog works. These settings are used by Snap-Master only and are not sent to the external equipment.

Pacing

The main pacer for the external equipment may come from within the equipment or from a special Snap-Master pacer. If the equipment automatically produces a new reading, the Multiple Query checkbox in the Strings dialog (which specifies the ASCII strings used to communicate with the equipment) should be turned off and the Sample Interval value should be the rate at which the equipment updates. To use Snap-Master as the pacer, then the Multiple Query checkbox should be turned on and the Sample Interval value specifies how often Snap-Master sends out a Query string. Refer to the Strings section for more information.

Because many RS-232 instruments communicate at very low rates, the pacing value for the RS-232 element is sometimes specified as the interval between samples rather than as a sample rate. Any interval greater than zero will be accepted as a Sample Interval. However, this does not mean that Snap-Master will always read data from the instrument at exactly this rate. The performance of Snap-Master depends on the speed of your computer, the speed of the serial communications, the number and types of other elements in the instrument, etc. Some experimentation may be required to determine the performance range of Snap-Master using this element.

Channels

The Channels list contains the channels specified in the Format line from the Instrument Response Format of the Strings dialog. The RS-232 element supports up to 32 channels of data, numbered from 0 to 31.

To define which channels are processed in Snap-Master, select the channel or group of channels from the list. Note that this does not turn channels on and off on the actual piece of equipment, it is only used by Snap-Master to determine which channels of data will be available to the other elements in the instrument.

Device

The Device group contains the Configuration button and the Device List. The Configuration button opens the Configuration dialog which specifies the settings for the computer's serial ports (also called COM ports). Finally, the Device List selects the Configuration to be used for this element.

String Assignments

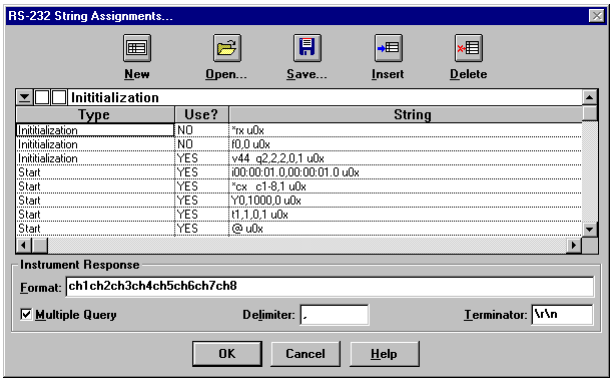


Figure 10-2 RS-232 String Assignments

The String Assignments dialog defines the different ASCII strings sent and received by Snap-Master from the external equipment. The string table specifies the strings used for specific events and if they are used by Snap-Master in the instrument. In addition, the Instrument Response defines how Snap-Master requests and interprets the incoming data.

The strings defined in this dialog are stored in the Snap-Master instrument file. This way, when you open this instrument at a later date, the original string set is preserved. In addition, you can save the contents of the table in a separate file, similar to saving a Display settings or a Sensor assignments file.

String Table Parameter Files

The New, Open, and Save buttons above the string table enable the user to store and recall the contents of the String Assignments dialog. These string files are saved using a "232" extension (for example, TEST.232). (The actual files are saved in a binary format, so you cannot edit them with a text editor).

String Table

The string table specifies the actual command strings sent by Snap-Master over the serial port to the external equipment. Up to twelve separate strings can be saved in the table. For each command, you specify the command Type, if it is used in this instrument, and the ASCII String sequence accepted by the external equipment.

Type

The **Initialization** command sends the string once at the start of a frame, which is often used to configure the external equipment before data collection begins. This command requires a response to come back from the RS-232 device. Minimally, this response string must contain a terminator.

The **Initialization - No Response** command is sent once at the start of a frame, but it does not wait for a response from the device. Use this type for devices which do not respond after commands.

A **Start** command informs the equipment to begin collecting data. This command also requires a response from the RS-232 device which must contain a terminator.

The **Start - No Response** command is sent at the start of a frame, but it does not wait for a response from the device.

The **Stop** command informs the equipment to stop data collection.

The **Query** command is used by Snap-Master to receive the next set of data. The format of the incoming data and frequency of the Query command are specified by the settings in the Instrument Response group. Only one Query command string is allowed per string table.

At the beginning of a frame, the string types are sent in the following order:

Initialization - No Response
Initialization
Start - No Response
Start
Query

If the string table contains more than one string definition for a specific command, then Snap-Master sends each active string in the order found in the table, moving from top to bottom.

Use?

Specifies whether or not the command string is sent out by Snap-Master (**YES**), or if the string is not used (**NO**).

String — Contains the ASCII character sequence sent by Snap-Master over the serial port to the external equipment for each corresponding command Type. Please refer to the manual for your specific equipment for the correct string sequences. The String contents may contain any ASCII character, along with special "C" like escape sequences for specific characters, as listed below:

Escape Sequence	Meaning
\b	Backspace
\f	Formfeed
\n	Newline
\r	Carriage return
\t	Horizontal Tab
\"	Double Quote
\'	Single Quote
\0	Null
\\	Backslash
\v	Vertical Tab
\a	Bell
\x	Hexadecimal constant

Table 10-1 RS-232 Escape Sequences

Instrument Response

The Instrument Response group defines how Snap-Master requests and interprets the incoming data from the external equipment. These settings are used by the Query command in the string table.

Snap-Master assumes that the ASCII string, or "data packet", returned over the serial port contains up to 32 pieces of information, called "tokens", each separated by a delimiter. A special termination character is used to indicate the completion of the string. In general, the string would look like this for one channel:

token termination

Or it would look like this for multiple channels:

token1 delimiter token2 delimiter ... token25 termination

The overall format of this string returned over the serial port is described in the Format text box. Each token is separated by a space in the Format description, without including the Delimiter or the Termination characters. The Format description should look like this:

token1 token2 token3 ... token24 token25

There are three types of information contained in a token: a Literal Match, a Place Holder, and Channel Data. Both the Literal Match and Place Holder tokens may contain any ASCII character or character sequence, but Channel Data tokens may contain only contain floating point numbers. Each token type, along with the syntax used to specify the token type, is described in detail.

Token Type	Syntax	Description
Literal Match	"ABCDEFG"	A Literal Match character or character sequence is enclosed in double quotes. If the characters in the incoming string do not match the Literal Match characters, an error is logged in the Status Log and the RS-232 element is stopped. This can be used for error condition checking for some instruments.
Place Holder	'123ABC'	A Place Holder character or character sequence is enclosed in single quotes. Any information in the incoming string interpreted as a Place Holder is ignored by Snap-Master. The length of the text in the Place Holder is ignored.
Channel Data	CH#	A Channel Data token is indicated using a CH#, where the # is replaced by the channel number to be used by Snap-Master. Valid channel numbers range from 0 to 31. The incoming string is interpreted as a floating point number.

Table 10-2 RS-232 Tokens

Format — Describes the tokens in each ASCII string.

Multiple Query — When selected, the Query string is sent out by Snap-Master multiple times at every pacing interval. When turned off, the Query string is sent only once.

If the external equipment is being used as the pacer, then the Multiple Query checkbox should be turned off. This means that the Query string is sent only at the beginning of each frame. If you want to use Snap-Master as the pacer to request a new data point at the rate specified by the Sample Interval, turn the Multiple Query check box on.

Delimiter — Defines the character sequence separating each data token. May include the Escape Sequences described above. Only one Delimiter definition is allowed and cannot change between data packets. In addition, the Delimiter must be different than the Terminator and the Terminator cannot be a subset of the Delimiter. For example, if the Terminator is *\r\n*, then the Delimiter cannot contain this sequence.

Termination — Defines the character sequence separating each data packet. May include the Escape Sequences described above. Only one Termination definition is allowed and cannot change between data packets. In addition, the Delimiter must be different than the Terminator and the Terminator cannot be a subset of the Delimiter.

Configuration

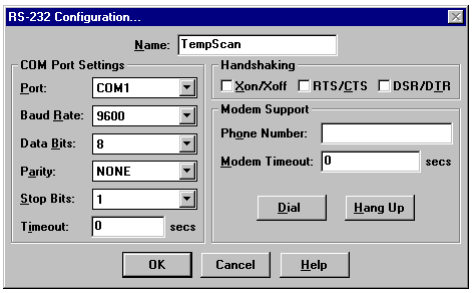


Figure 10-3 RS-232 Configuration

The Configuration dialog defines the serial communication parameters for up to eight separate devices. Each device can be assigned a unique name using the Name text box. The Name is also included in the element's icon title. To open this dialog, select the Configuration button from the Settings dialog.

COM Port Settings

Port	Select the serial port the instrument is connected to. There can be only one instrument per serial port.
Baud Rate	Specifies the baud rate of the incoming data. This setting must match the rate at which the external equipment sends and receives ASCII data and commands.
Data Bits	Specifies the number of data bits the equipment uses for communication.
Parity	Specifies the parity the instrument uses for communication.
Stop Bits	Specifies the number of stop bits the instrument uses for communication.
Timeout	Specifies the maximum amount of time in seconds that Snap-Master attempts to communicate with the external equipment. If this time period elapses and no communication takes place, an error occurs and is recorded in the Status Log. This time out should be greater than the Sample Interval.

Handshaking

The RS-232 element provides three methods of serial communication handshaking, which can be used alone or in combinations. Xon/Xoff is a software handshaking technique supported by many instruments, and the Xon and Xoff characters supported are Control-Q and Control-S respectively. RTS/CTS and DSR/DTR are hardware handshaking techniques which require proper cables. Consult your equipment's manual for handshaking support.

Modem Support

The Modem Support group provides modem support for remote instruments connected to a Hayes compatible modem. When the Dial button is pressed, Snap-Master sends a modem initialization string ("ATZE0V1 S0=0\r\n") and dial command string ("ATDTphonenumber\r\n"). Once a connection has been established the element works as usual. When acquisition has been completed the modem connection should be closed by pressing the Hang-up button which sends the hand up command string ("ATH\r\n") to the modem. If the Hang-up command is not issued, the serial port will remain open and unavailable for use to other applications even after closing Snap-Master.

Phone Number	Specifies the phone number to be dialed with the Dial button.
Modem Timeout	Specifies the amount of time in seconds Snap-Master waits for a connection (carrier detect) before failing the Dial command. Note that this check is done in hardware by checking the status of the Carrier Detect pin (pin eight on a 25 pin connector, pin 1 on a 9 pin connector). If you are not using a modem to make a dial-up connection, set this value to 0 or you will receive timeout error messages.

10.2. Tutorial: Writing Example RS-232 Strings

The Hydra Data Logger by John Fluke Manufacturing is an external piece of equipment which communicates over RS-232. This equipment can be configured to return a single channel of data in response to a query string.

To accomplish the task of returning the data from channel 0 on the Hydra, the string table would look like the following (note that these string sequences are specific to the Hydra; consult the manual for your specific equipment for the proper string sequences):

Type	Use?	String
Initialization		*RST; FUNC 0, VDC, AUTO \n
Query		SCAN 1; NEXT?;SCAN 0\n

If you were to send out this set of commands using a terminal emulator (such as the Terminal program included with Windows), then the data logger's response to this would look like this:

8,0,0,1,1,93,7.939E+0,15,255,00.000E+3\r\n=>\r\n

As we can see from the response, the Delimiter is a comma. The Terminator for this string is either "\r\n=>\r\n" or "=>\r\n". If the Terminator was set to "\r\n", then the "=>\r\n" would be interpreted as the next response, and an error condition would occur.

Because it is not obvious from the response what each of the tokens represent, we must consult the Hydra Data Logger's manual. It says that the first six tokens are the hour, minute, seconds, month, day, and year respectively (which would be 8 AM on January 1, 1993 in the above string). The seventh token is the floating point value for Channel 0. The last three tokens are the alarm output, digital I/O, and counter values.

Because our example is only interested in the data in channel 0, the settings in the Instrument Response group would look like this:

Format:	'HOUR' 'MINUTE' 'SECOND' 'MONTH' 'DAY' 'YEAR' CH0 'ALARM' 'DIGITAL' 'COUNTER'		
Delimiter:	,	**Terminator:**	=>\r\n

The first six tokens ('HOUR' through 'YEAR') and the last three tokens ('ALARM' through 'COUNTER') are Place Holders and are ignored by Snap-Master, which is indicated by the single quotes used to describe them. The characters between the single quotes are not important and could have been called anything, such as 'A' 'B' 'C', etc. However, we have opted to include a meaningful description of the token.

The seventh token, CH0, indicates that this is a value to be assigned to channel 0 of this element. By including this CH0 token, the channel list in the Settings dialog will contain A0 (or whatever the element letter of this element is). Each time a Query is sent, the response is read and this token will be converted to a new data point for channel 0 of the element. If the channel is selected in the Channel list, then other elements in the Snap-Master instrument have access to this data..

Because the Hydra Data Logger only returns one point of data per query in this configuration, the Multiple Query check box is turned on. This means that the Query string is sent at the interval specified in the Sample Interval text box in the Pacing group of the Settings dialog.

Chapter 11. Data Output

11.1. Analog Output (D/A) 11-1
11.2. Digital Out 11-3
11.3. Tutorial: Outputting Analog Data.....11-4
11.4. Tutorial: Outputting Digital Data 11-7

11.1. Analog Output (D/A)

The D/A element converts digital information from Snap-Master into an analog signal using digital-to-analog hardware. Snap-Master allows you to use multiple D/A devices in an instrument. This hardware must be properly configured in both hardware and software for proper operation. Please refer to the hardware documentation for information on its features and its use with Snap-Master.

D/A Settings

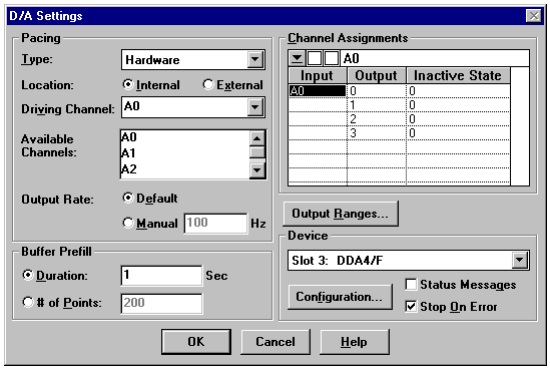


Figure 11-1 D/A Settings

Pacing

Type

Software pacing relies on the computer's timer to determine when to output a new data point, which is limited to around 20 times per second. All channels in the instrument are available for D/A output.

Hardware pacing outputs a new data point at precise time intervals using a dedicated pacing clock on the D/A hardware. The output rate of the data then relies on the capabilities of the D/A hardware to perform high speed data transfer between Snap-Master and the board.

If this control does not appear, software pacing is used.

Driving Channel

When Hardware pacing is used, this determines which channels are available for output. Only channels that share the same element letter as the Driving Channel can be selected in the Channel Assignments table, as listed in the **Available Channels** list.

Output Rate	When a Driving Channel is selected, the Sample Rate portion of the frame characteristics are used to set the **Default** rate. You can specify a different update rate using **Manual** and entering the new rate.

Buffer Prefill

For Hardware Pacing, this specifies the amount of data sent to the D/A output buffers before actual signal generation begins. The size of the buffer may be specified as a **Duration** or as a **Number Of Points**.

This prefill buffer is used to keep a certain amount of data available for the D/A while more data is made ready for it. If the D/A empties the buffer before the driving element can fill it, a "D/A Underrun" error is sent to the Status Log.

Channel Assignments

Input	Assigns a data channel from Snap-Master to the Output channel.
Output	Specifies the output channel on the D/A device. This column is not editable. The value of the analog output channel is equal to the Input channel, as long as it is within the output range of the D/A converter. If the value is outside the range of the D/A converter, then the analog output channel will go either to its minimum or maximum value, depending on whether the input is greater than or less than the output range.
Inactive State	Specifies the voltage output by the D/A channel between frames and when the instrument stops. Enter a value within the output range of the channel, or type "HOLD" to maintain the last value of the frame.

Device

The Device section lists the currently installed devices and their device numbers. Because Snap-Master supports multiple hardware devices running simultaneously, each piece of hardware is assigned a unique number. (Hardware that has multiple functions, such as A/D, D/A, and Digital I/O, uses the same device number). By default, each time you include a new element in an instrument, device 1 is selected. To use a different device, select the proper device number from the list.

When the Status Messages check box is selected, run-time information about the element is sent to the Status Log. Under normal operation, this option should be turned off. If an error is encountered during operation of the instrument, the message will be sent to the Status Log regardless of the Status Messages setting.

When the Stop On Error check box is selected, any errors (underruns or overruns) encountered during operation of the instrument causes the instrument to stop immediately. When the check box is turned off, the element continues operating in spite of the error.

11.2. Digital Out

The Digital Out element controls the digital output channels (or bits) of digital I/O hardware. Snap-Master allows you to use multiple Digital Output devices in an instrument. This hardware must be properly configured in both hardware and software for proper operation. Please refer to the hardware documentation for information on its features and its use with Snap-Master.

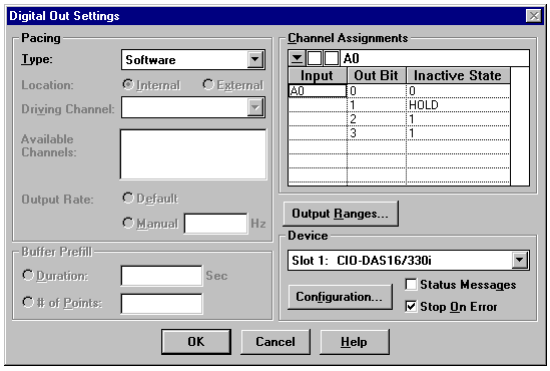


Figure 11-2 Digital Out Settings

The Digital Out Settings dialog operates in the same fashion as the D/A Settings dialog box. Pacing, Buffer Prefill, and Device groups have the same meaning for the Digital Out as the D/A element. (If the Pacing and Buffer Prefill groups do not appear, assume that the Pacing Type is Software.) The main difference between the elements is the type of data output, with the Digital In element outputting digital data.

Channel Assignments

Input — Assigns a data channel from Snap-Master to the Output bit.

Output — Specifies the output bit on the device. This column is not editable. The output bits appears as entries in the table in the order of Least Significant Bit (LSB) to Most Significant Bit (MSB).

When the value of the input channel is greater than or equal to 1, the digital bit is set to 1 (True). When the value is less than 1, then the digital bit is set to 0 (False).

Inactive State — Specifies the state of a digital output bit between frames and when the instrument stops. The available options are 0 (False), 1 (True), and HOLD, which retains the last state of the digital output bit when the frame ends or the instrument stops.

11.3. Tutorial: Outputting Analog Data

In this tutorial, we will output the simple 0.5 Hz sine wave from the A/D Demo element over a D/A channel. To verify the signal output through the D/A, we will acquire the output of the D/A using the A/D function of the hardware. (If you do not have A/D hardware, you could hook up an oscilloscope or meter to the D/A output).

Building the Instrument

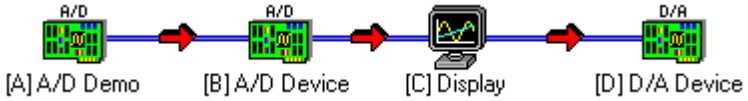


Figure 11-3 Instrument for Analog Output Tutorial

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place the A/D Demo element, an A/D element, a Display element, and a D/A element in the instrument.

> You will need to use the pop up menu in the Toolbox to place both the A/D Demo and an A/D device in the instrument. The menu selection that has a check mark by it indicates which A/D board will be placed in the instrument when the icon is dragged to the instrument window. To change the selection, click on the desired driver.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the A/D Demo to the A/D hardware element, the A/D hardware element to the Display element, and the Display element to the D/A hardware element.

> Remember that data flows through elements, so we will still be able to plot the A/D hardware information.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as D2A.

Configuring the A/D Demo

1. Open the A/D Demo Settings by double clicking on the [A] element.

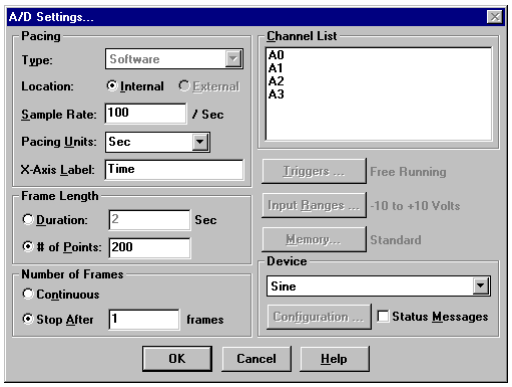


Figure 11-4 A/D Demo Settings

2. Change the Number of Frames to Stop After 1 frame.

3. Press the OK button to close the A/D Demo Settings.

Configuring the A/D Hardware

Make sure you have a physical connection on the hardware's termination panel for the output of D/A channel 0 (or channel 1) to A/D channel 0 (or channel 1).

1. Open the A/D Settings by double clicking on the [B] A/D element.

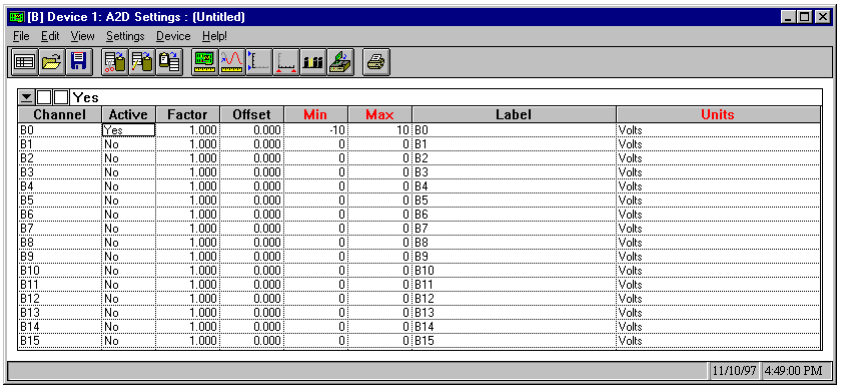

[B] Device 1: A2D Settings : (Untitled)
File Edit View Settings Device Help
Yes
Channel Active Factor Offset Min Max Label Units
B0 Yes 1.000 0.000 -10 10 B0 Volts
B1 No 1.000 0.000 0 0 B1 Volts
B2 No 1.000 0.000 0 0 B2 Volts
B3 No 1.000 0.000 0 0 B3 Volts
B4 No 1.000 0.000 0 0 B4 Volts
B5 No 1.000 0.000 0 0 B5 Volts
B6 No 1.000 0.000 0 0 B6 Volts
B7 No 1.000 0.000 0 0 B7 Volts
B8 No 1.000 0.000 0 0 B8 Volts
B9 No 1.000 0.000 0 0 B9 Volts
B10 No 1.000 0.000 0 0 B10 Volts
B11 No 1.000 0.000 0 0 B11 Volts
B12 No 1.000 0.000 0 0 B12 Volts
B13 No 1.000 0.000 0 0 B13 Volts
B14 No 1.000 0.000 0 0 B14 Volts
B15 No 1.000 0.000 0 0 B15 Volts
11/10/97 4:49:00 PM

Figure 11-5 A/D Hardware Settings

2. Press the button, or select the Settings menu, Frame Settings command.

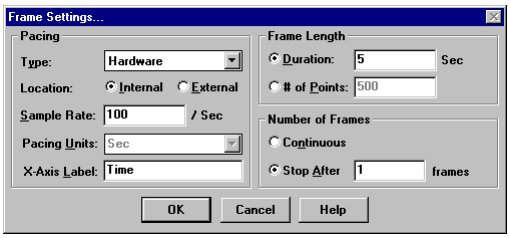


Figure 11-6 A/D Frame Settings

3. Set the Type to Hardware.

4. Change the Sample Rate to 100.

5. Change the Frame Length to a Duration of 5 seconds.

6. Change the Number of Frames to Stop After 1 frame.

7. Press the Frame Settings.

6. Save the instrument with the button or select the File menu, Save Instrument command.

Configuring the D/A

We need to assign a channel to one of the D/A channels. The data values of this channel are used to set the value of the analog output. Again, make sure you have a physical connection on the hardware's termination panel for the output of D/A channel 0 (or channel 1) to A/D channel 0 (or channel 1).

1. Open the D/A Settings by double clicking on the D/A element.

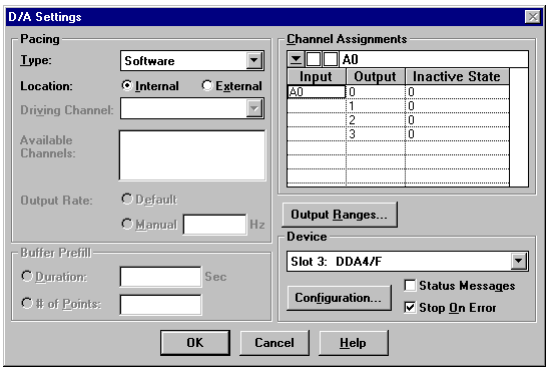


Figure 11-7 D/A Settings

2. Set the Input channel for Output 0 to A0.

   This assigns the data from channel A0 (the 0.5 Hz sine wave from the A/D Demo) to output channel 0. If your D/A hardware does not have a channel 0, use channel 1 instead.

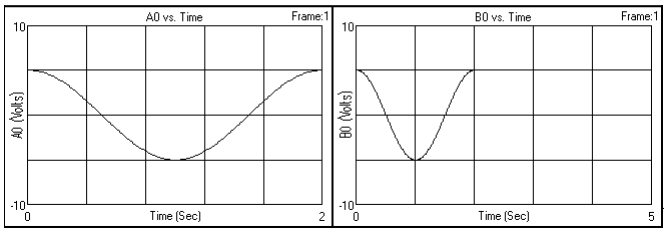
3. Press the OK button to close the D/A Settings.

4. Save the instrument with the button or select the File menu, Save Instrument command.

Running the Instrument

Before starting the instrument, make sure you have a physical connection on the hardware's termination panel for the output of D/A channel 0 (or 1) to A/D channel 0 (or 1).

1. Press the START button or the Start! menu command.



If all is well, the Display window opens and begins plotting both the output of the A/D Demo, as well as the same signal from the A/D hardware. Notice that after two seconds, the signal on the A/D hardware channel goes to 0. This is because the A/D Demo has finished its frame and produces no more data and the Inactive State of the D/A channel is 0.

If the test does not go as expected, make sure you have the proper signal connections and software settings. If the Status Log appears with an ERROR entry, follow the remedy listed. If all else fails, verify the hardware Configuration.

11.4. Tutorial: Outputting Digital Data

Outputting data with the Digital Out element uses the same steps as sending data out using an D/A element. Let's use a similar approach as before, this time without reacquiring the data. For a digital signal, try connecting the Digital Output to an LED (or meter) to indicate digital high (on) and low (off).

Building the Instrument

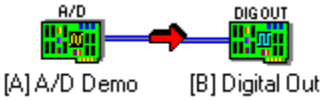


Figure 11-8 Instrument for Digital Output Tutorial

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place an A/D Demo element and a Digital Out element in the instrument.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the A/D Demo element to the Digital Out element.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as DIGOUT.

Configuring the Digital Out Element

1. Open the Digital Out Settings by double clicking on the element.

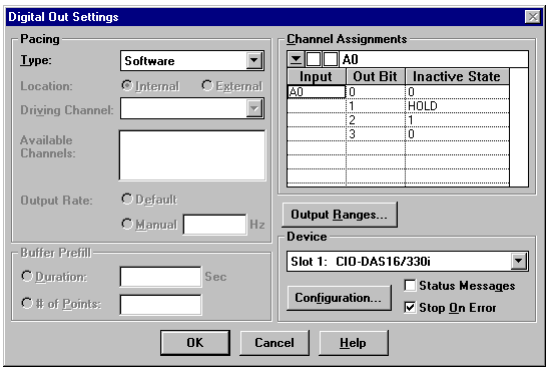


Figure 11-9 Digital Out Settings

2. Set the Input channel for Out Bit 0 to A0.

   This assigns the data from channel A0 (the 0.5 Hz sine wave from the A/D Demo) to output channel 0. If your hardware does not have a bit 0, use bit 1 instead.

3. Press the OK button to close the Digital Out Settings.

4. Save the instrument with the button or select the File menu, Save Instrument command.

Running the Instrument

1. Press the

button or the Start! menu command.

When the instrument runs, you should see the LED turn on and off (or the meter reads high and low values) about 2 times every second. If the test does not go as expected, make sure you have the proper signal connections and software settings. If the Status Log appears with an ERROR entry, follow the remedy listed. If all else fails, verify the hardware Configuration.

Chapter 12. Analysis and Frequency Analysis

12.1. Menu Commands **12-4**
12.2. Functions **12-11**
12.3. Equation Syntax **12-26**
12.4. Tutorial: Adding Two Channels **12-28**
12.5. Tutorial: Performing A Block Average **12-32**
12.6. Tutorial: Finding When An Event Occurs **12-34**
12.7. Tutorial: Integrating Over A Specific Range Of Data **12-37**
12.8. Tutorial: Defining Your Own Functions **12-40**

This chapter describes the functionality of two elements: the Analysis element (which processes time-domain data channels) and the Frequency Analysis element (which processes the magnitude portion of frequency domain data channels). Functionally the elements are the same, with the exception of the type of data they process.

Analysis

This element is included with the Snap-Master Waveform Analyzer (SM-WA) module.

The Analysis element performs calculations on time domain data channels from other elements. The built-in functions include arithmetic, trigonometric, statistical, calculus, logical, and filtering. In addition, user-defined functions can be defined which combine the built-in functions.

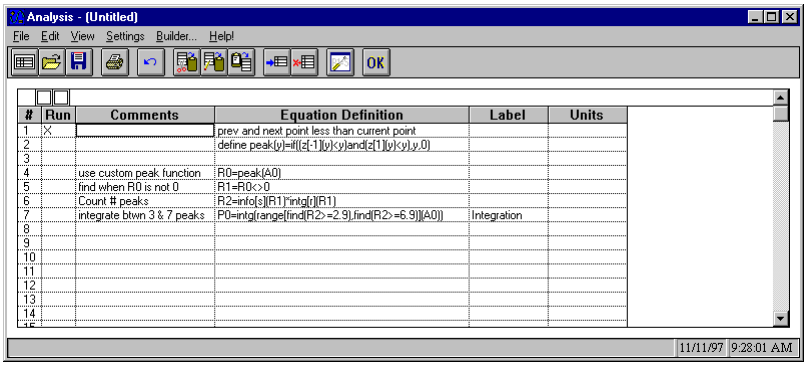


Figure 12-1 Analysis Element

Frequency Analysis

This element is included with the Snap-Master Frequency Analyzer (SM-FA) module.

The Frequency Analysis element operates on the magnitude portion of frequency domain data channels using the same processing functions available in the Analysis element. To convert time domain data to the frequency domain, use the FFT element.

Phase, real, and imaginary representations of the data channels are not available from this element. Only the enhanced syntax is supported, and the phase portion of all result channels is set to 0.

All references to the Analysis element throughout this chapter refer to both the time domain Analysis element as well as the Frequency Analysis element.

Command Bar

The Command Bar buttons unique to the Analysis elements are:

Opens the Equation Builder.

Checks the equations for errors. The button says

when the table check is successful..

Table Columns

In the Analysis equation table, all columns except the # (Line Number) column are editable. If you attempt to edit the # column, you will be informed that editing is not available. The following columns are listed in the Analysis equation table:

#	Specifies the line number of the equation. This line number is used to reference the contents of the equation in another equation, which is often used to define constants (for example, #9 references the constant in row 9 of the table).
Run	Using the Enhanced Syntax, this column specifies if the equation in the row is active (the Run cell is blank) or inactive (indicated by a X in the cell, so the equation is ignored). Using the Original Syntax, the active equation is indicated by a * in the Run cell.
Comments	Cell where each equation is described. Each comment can be up to approximately 250 characters long.
Equation	Cell where the actual equation or equation macro (using the Original Syntax) is defined. Each equation can be up to approximately 250 characters long.
Label	Allows the user to define a channel label for all result channels defined in the Equation Definition. If the equation line contains an equation macro (using the Original Syntax), then the label is assigned to all result channels defined in this line.
Units	Allows the user to define the units for all result channels defined in the Equation Definition. If the equation line contains an equation macro (using the Original Syntax), then the units are assigned to all result channels defined in this line.

Quick Function Reference

Please refer to section 12.2 for more information on the individual functions.

Function	Syntax	Notes
Addition Subtraction Multiplication Division Power	arg1 + arg2 arg1 - arg2 arg1 * arg2 arg1 / arg2 arg1 ^ arg2	[o] Oversampling [u] Undersampling
Absolute Square Root Exponential Log (Base 10) Natural Log	abs(arg1) sqrt(arg1) exp(arg1) log(arg1) ln(arg1)	
Cosine Sine Tangent ArcCosine ArcSine ArcTangent	cos(arg1) sin(arg1) tan(arg1) acos(arg1) asin(arg1) atan(arg1)	[d} Degrees [r] Radians [g] Grads
Differentiation	diff(arg1)	[2] 2 Point [3] 3 Point [5] 5 Point [t:1] 1st Order Taylor [t:2] 2nd Order Taylor [t:4] 4th Order Taylor
Integration	intg(arg1)	[r] Rectangular [s] Simpson's Rule [t] Trapezoidal [a:*order*] Adams-Bashforth (1-6) [g:*order*] Gear's (1-6)
Y-X Integration	intgyx(arg1,arg2)	area under the curve of arg1 with respect to arg2
Correlation	arg1 corr arg2	[o] Oversampling [u] Undersampling
Average Maximum Minimum Root Mean Sqr Std Deviation Variance	avg(arg1) max(arg1) min(arg1) rms(arg1) std(arg1) var(arg1)	produces single point result
Running Avg Runing Max Running Min Running RMS	ravg(arg1) rmax(arg1) rmin(arg1) rrms(arg1)	produces array result
AND OR XOR Comparison	arg1 and arg2 arg1 or arg2 arg1 xor arg2 arg1 *compare* arg2	[o] Oversampling [u] Undersampling *compare* <. <=. =, >=, >, <> true = 1, false = 0 values >= 1 are true
NOT	not(arg1)	
If..Then..Else	if(arg1, *true_res*, *false_res*)	arg1 >= 1 produces *true_res* arg1 <1 produces *false_res*
Find Time Of Event	find(arg1)	[p] Frame Point Number [t] Frame Time
Smoothing Filter	filter(arg1)	

Function	Syntax	Notes
FIR Filter	fir[*order*,*type*,*f1*, *f2*,*window*](arg1)	*order* 1 to 400 *type* l - Low Pass (f1) h - High Pass (f1) p - Band Pass (f1, f2) r - Band Reject (f1, f2) *f1* cutoff frequency 1 *f2* cutoff frequency 2 *window* M - Hamming N - Hann B - Blackman-Harris K - Kaiser-Bessel R - Rectangular
IIR Filter	iir[*order*,*type*,*f1*, *f2*,*family*,*p1*,*p2*] (arg1)	*order* 1 to 400 *type* l - Low Pass (f1) h - High Pass (f1) p - Band Pass (f1, f2) r - Band Reject (f1, f2) *f1* cutoff frequency 1 *f2* cutoff frequency 2 *family* b - Butterworth t - Chebyshev (p1) e - Elliptic (p1, p2) i - Inverse Chebyshev (p2) *p1* Pass Band Ripple (in dB) *p2* Stop Band Ripple (in dB)
Frame Time	time time[*#pts*,*dur*] time(arg1)	*#pts* points per frame *dur* frame length in seconds produces current time of frame
Time Shift	z[*#pts*](arg1)	*#pts :* points to shift (positive or negative)
Range	range[*format*,*start*, *stop*](arg1)	*format :* *(optional)* p - Points t - Time *start* : start point *stop* : stop point array values 0 outside of range
Block	block[*format*,*#pts*, *overlap*](arg1)	*format:* *(optional)* p - Points t - Time *#pts*: size of block *overlap*: *(optional)* amt of overlap
Fraction Round Truncate	frac(arg1) round(arg1) trunc(arg1)	fractional portion only rounded integer integer portion only
Modulus	arg1 mod arg2	[o] : Oversampling [u] : Undersampling remainder portion of division
Channel Information	info[*type*](arg1)	**Time Domain** [s] : Sample Rate [p] : Frame Duration in Points [t] : Frame Duration in Seconds **Frequency Domain** [s] : Resolution [p] : Window Width [t] : Maximum Frequency
Pi	pi	single value 3.14159...
Pulse	pulse	array of 1 at center, 0 elsewhere

12.1. Menu Commands

Please refer to Chapter 2 for a description of the common menu commands.

File Menu

Open Settings

When you open a Snap-Master equation file, the Analysis element checks the current function defaults against the defaults stored in the .CLC file (or the .FCL file for the Frequency Analysis element).. If they are different, a message box appears asking if you want to change the function defaults to the ones stored in the file. In order to duplicate a previous test exactly, you should accept the changes.

Importing Snap-Calc Files

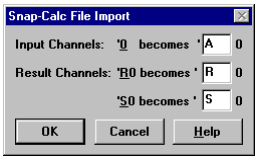


Figure 12-2 Channel Mappings for Importing Snap-Calc Files

For SnapShot users, Snap-Calc files can be imported using the Original Syntax option (refer to section 12.1.0 for more information on the syntax options). When importing a Snap-Calc file, the Channel Mappings dialog box defines the input, result ('R), and single value ('S) element letters. You can change these to the element letters in your particular instrument using the appropriate text boxes.

Semicolons are not supported in Snap-Master. Instead, you must use parentheses to compose the equation. Also, if the Time function is used to generate a signal, you may need to specify the number of points and frame duration for the 't function. In Snap-Calc, this was always referenced to the current Sample Rate and Sweep Time settings in Snapshot.

Equations using the following Snap-Calc functions are not available using the Snap-Master Analysis element:

Snap-Calc Operator	Description	Snap-Master Usage
g	Graph	Use Display element
h	FFT	Use FFT element
o	Output	
z	Coordinate conversion	

Merge Equations

Merge a file into the current table. This could overwrite equations already in the Analysis table, so make sure to create backup copies of your equations by saving them before merging.

Builder Menu

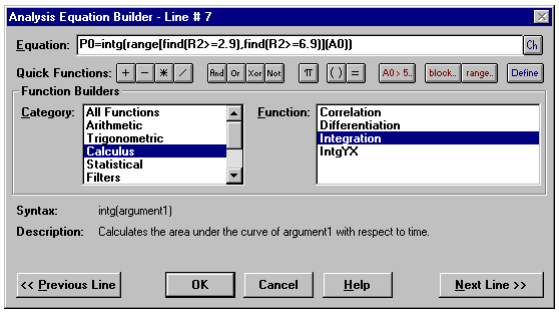


Figure 12-3 Equation Builder

The Equation Builder provides a simple method of creating and editing the contents of the Analysis equation table.

The Equation edit control is where the actual building of the equation is performed. You can type the equation in this text box just as if you were using the standard equation table. However, what makes the Equation Builder useful is that you can build the equation by clicking on the Quick Function buttons and double clicking on the Function list items.

When you click on the

button located at the right side of the Equation edit control, a pop up list appears which contains the defined channels in the instrument. If a channel has been assigned a label, then the label also appears in the pop up list. To insert a channel in the Equation Line at the current cursor position, select the channel from the pop up list.

The Quick Function buttons are used to insert the most commonly used functions into the Equation edit control or to open the Function Builder where applicable. All of the available Quick Function buttons appear in the main Equation Builder. In the Function Builders, Quick Function buttons that best apply to the function are shown.

The Category and Function lists organize the functions alphabetically into different groups. The All Functions category lists all available functions in the Function list. Alternatively, you can select a specific category to narrow down the items shown in the Function list.

When you click once on a function in the Function list, the proper Syntax (along with any options) for the function is shown along with a description about the function. To open the Function Builder for the item, double click on the list item.

When you are finished using the Equation Builder, press the OK button to write the contents of the Equation edit control to the line number indicated in the title of the dialog. To abort the changes for this line, press the Cancel button. You may also use the Previous Line and Next Line buttons to navigate through the equation table without leaving the Equation Builder.

Quick Function Buttons

Quick Function buttons are available in both the main Equation Builder and the Function builders. The available Quick Function buttons are described as follows:

+	Insert or replace the selected text with +
−	Insert or replace the selected text with -
*	Insert or replace the selected text with *****
/	Insert or replace the selected text with /
And	Insert or replace the selected text with **and**
Or	Insert or replace the selected text with **or**
Xor	Insert or replace the selected text with **xor**
Not	Insert or replace the selected text with **not**
π	Insert or replace the selected text with **pi**
( )	Insert or enclose the selected text in **( )**
=	Insert or replace the selected text with =
A0 > 5..	Open the Comparison Function Builder
block..	Open the Block Function Builder
range..	Open the Range Function Builder
Define	Insert or replace the selected text with **define**
find..	Open the Find Time of Event Function Builder

On-Screen Keypad

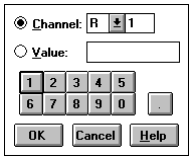


Figure 12-4 On-Screen Keypad

The Equation Builder and the Function Builders have access to the On-Screen Keypad which allows you to enter new channel numbers or constant values using your mouse. To open the On-Screen Keypad, click on an edit control using the right mouse button.

To define a channel, select the Channel radio button, the element letter of the new channel, then use the on-screen keypad to enter the channel number. To enter a value only, select the Value radio button and use the On-Screen Keypad to enter the value.

Function Builders

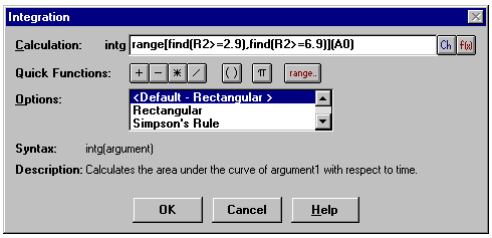


Figure 12-5 Function Builder for Integration

When you double click on a function in the Function list, a special dialog called a Function Builder opens. Each Function Builder is designed to guide you through the required function arguments and optional parameters for the function. The complete syntax for the function along with a description for the active control is displayed at the bottom of each Function Builder.

The required number of arguments for the function is indicated at the top of the dialog by the number of available edit controls. Any applicable Quick Function buttons are shown, along with a list of Options for the function. For example, the Integration function shown in Figure 12-5 has a single argument and a list of options (the different integration methods) to choose from.

Once you are in a Function Builder, you can nest calculations using the f(x) button. When you press the function button, a pop up list appears which contains the built-in Analysis functions organized by category (using the same Category list from the main Equation Builder).

Selecting a function from the function pop up opens an additional Function Builder for the new function. When you press the OK button in the Function Builder, the contents are passed back to the previous Function Builder until you reach the Equation Builder.

Settings Menu

Analysis Settings

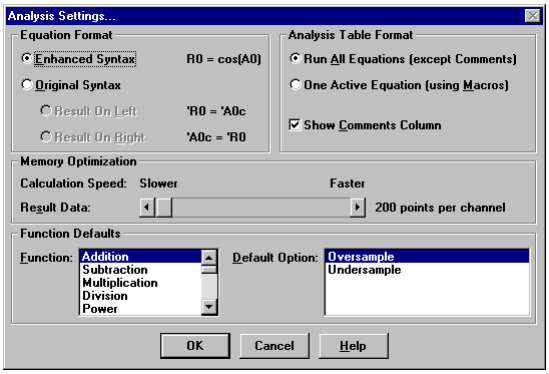


Figure 12-6 Analysis Settings

Equation Syntax

The Equation Format has two main choices: either the Enhanced Syntax (for example, R0 = cos(A0)) or the Original Syntax (the equivalent equation would be ‘R0 = ‘A0c). In addition, the Original Syntax can specify the result channel either on the Left or Right side of the equal sign.

We recommend using the Enhanced Syntax for all new Snap-Master instruments because you will then be able to access all of the built in functions using the Enhanced Syntax. The Original Syntax and its options are provided for backwards compatibility with files created by Snap-Calc and Snap-Master (version 2.x and earlier).

Analysis Table Format

The Analysis Table Format group specifies how the equation table operates. The Run All Equations option uses all active equations in the equation table for its results processing. Active equations are indicated by a blank cell in the **Run** column, so rows with an X in the **Run** column are not processed. When the One Active Equation option is selected only one equation line can be active at a time, so equation macros are used to process multiple equations (used with previous versions of Snap-Master).

The Show Comments Column check box determines if the Comments column is visible in the Equation Table. When using the Run All Equations option, you may want to hide the Comments column to increase your screen real estate by writing comments in-line with the equations and turning on the X in **Run** column.

Memory Optimization

The Result Data scroll bar lets you set the number of points per channel that are stored in memory by the Analysis element. This setting affects all functions, but has a more dramatic impact on the Time Shift, Range (especially when using the Find Time Of Event function to define the Start and Stop parameters), and similar functions. The Analysis element stores between 100 and 16,000 points per channel based on this setting.

There is a tradeoff between the number of points stored in memory and the speed of the calculations. In general the less the number of points stored in memory the slower the calculations will occur, and the greater the number of points the faster the calculation. We recommend setting the number of points to around 1000 for optimal performance.

Function Defaults

For built-in functions that have multiple processing options, you may specify the default option used when the function is specified by itself. The current default option is indicated by an outlined check mark. To change the default, select the function from the Function list and double click on the desired option.

All instruments and Analysis elements share a common set of Default Options. This means that is you have two Analysis elements in an instrument or two instruments open each with an Analysis element, then they all must have the same default options for each function. (The Frequency Analysis element has its own default settings which are separate from the Analysis element).

When you save the instrument or equation file, the current default options are also saved. When you open an instrument or equation file, Snap-Master checks the current function defaults in the Analysis element against the defaults stored in the .CLC file (or the .FCL file for the Frequency Analysis element). If they are different, a message box will appear asking you if you want to change the function defaults to the ones stored in the file. In order to duplicate a previous test exactly, you should accept the changes by answering yes.

Frame Characteristics

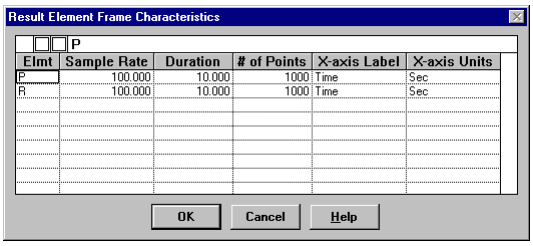


Figure 12-7 Frame Characteristics Table

Table Columns

Elmt Element letters assigned by Analysis element. You cannot enter new element letters in this table; you must assign new result elements using the equation table.

Sample Rate Displays the sample rate for the Analysis element.

Duration Displays the length (in seconds) for each frame of data for the Analysis element.

Resolution Displays the frequency resolution for the Frequency Analysis element.

Freq Range Displays the maximum frequency for the Frequency Analysis element result channel.

# of Points Displays the number of points in the each frame of data.

X-Axis Label Specifies the Label used by the X-Axis. For the Analysis element, the default label is Time. For the Frequency Analysis element, the default label is Frequency.

X-Axis Units Specifies the units used to define the sample rate. For the Analysis element, the default units are seconds. For the Frequency Analysis element, the default units are Hz.

How Frame Characteristics Are Determined

Each element letter contains information about the number of points per frame and the duration of the frame, which are collectively called the frame characteristics of the element. For the Analysis element, the frame characteristics consist of the sample rate, which is equal to the points per frame divided by the frame duration in seconds. For the Frequency Analysis element, the frame characteristics are made up from the frequency resolution, the maximum frequency, and the number of points (or spectral lines).

When you create a new result element letter, Snap-Master uses the contents of the first equation to use the element letter to determine its frame characteristics. There are two main factors which affect the resulting frame characteristics:

- The output size (array, single point) of the first function called in the equation
- The frame characteristics of the input to the first function called in the equation
- If the frame characteristics cannot be determined for the Analysis element, a sample rate (or frequency resolution) of 1 Hz and a frame length of 1 point is assigned.

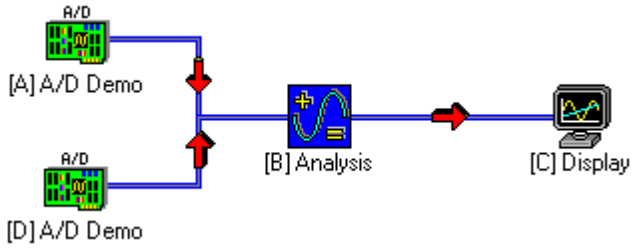


Figure 12-8 Example Instrument for Determining Frame Characteristics

To illustrate how frame characteristics are determined for the Analysis element, assume that element A has 100 points per frame and a frame length of 1 second (a sample rate of 100 Hz). Also, assume that element D has 400 points per frame and a frame length of 2 seconds (a sample rate is 200 Hz). The equation table in the Analysis element has the following equations:

#	Run	Comments	Equation Definition	Label	Units
1			R0 = A0		
2			S0 = avg(A0)		
3			T0 = A0 + D0		
4			Q0 = block[10](A0)		
5					

The simplest equation is shown in line #1 (R0 = A0). The output of the "equal function" is an array with the same number of points per frame as element A0. The result element letter R inherits the frame characteristics of element A, so all subsequent uses of element letter R will have a sample rate of 100 Hz and a frame length of 100 points per frame. Element letter R would have the same frame characteristics for other array functions using only element letter A, such as R0 = A0 + A1, R0 = cos(A0), etc.

Channel S0 is defined as the average of channel A0. In this case, the Average function produces a single point so element letter S has a frame length of one point. Any other equations using element letter S also have a frame length of one point. As a result, if you define an equation later in the table as S1 = A0 + A1, you will only see the result of the first data point because the frame length of element letter S is one point.

Line #3 shows the equation T0 = A0 + D0. The addition function produces an array, but the frame characteristics of the channels are different. In this case, Snap-Master checks the default option for the function being used. When the Oversampling option is selected (which is the recommended option), Snap-Master "oversamples" channel A0 to match the sampling rates of the two elements. In addition, the shorter frame length is assigned to the result element letter. As a result, the result element letter T has a sample rate of 200 Hz (from channel D0) and a frame length of 100 points (from channel A0). If Undersampling option was selected, then Snap-Master would undersample channel D0 and element letter T would have a sample rate of 100 Hz and a frame length of 100 points. The shortest frame length is always selected.

Finally, the Block function also affects the output length of the frame. In this case, the frame length for element letter Q is the frame length of element letter A divided by the block size (100 points per frame / 10 points per block = 10 points per frame for element letter Q). The Correlation function also affects the frame length for the result element letter.

Check Now

Whenever you enter or change an equation in the equation table, Snap-Master must check the equation for errors before running the instrument. If you attempt to start the instrument without checking the equations, a message box tells you that you must do so before starting the instrument.

If any errors are encountered while checking an equation, one of the following symbols appears in the **Run** column of the equation table. When you double click on the symbol, a dialog box appears which explains the error and lets you edit the equation.

The error symbols and the severity of the error are as follows:

Symbol	Severity	Description
	Warning	Does not prevent starting the instrument, but the results may not be what you intended.
	Error	Does not allow you to start the instrument without fixing the error.
	Fatal Error	Does not allow you to start the instrument and indicates a critical error. Occurs very rarely, so you should contact technical support if you receive a Fatal Error message.

Auto Check

Automatically check the equation table each time it changes.

12.2. Functions

Each function is presented in the following format:

Function Name

Syntax used to write the equation with the function shown in bold (functions that are italicized are replaced as described for the function), any required delimiters enclosed in brackets and written in bold italics, and the equation arguments.

Delimiters Any required function delimiters are explained. Delimiters always appear in brackets following the function. If no delimiters are available, this entry is not shown in the user's manual.

Options The syntax and description for any optional methods. Options are always enclosed in brackets following the function. If no options are available, this entry is not shown in the user's manual.

Examples Example equations using the function are illustrated.

A brief description of the function follows the general information. Any further information on the delimiters and options are also described.

Arithmetic Functions

Addition

arg1 + arg2

Options	[o]	Oversampling
	[u]	Undersampling
Examples		R0 = A0 + A1
		R0 = A0 +[o] A1

The Addition function adds the current point in arg1 to the current point in arg2. The frame characteristics for the function result are determined by the Options. We recommend that the Oversampling option is always used for the Default Option for this function.

Subtraction

arg1 **-** arg2

Options	[o]	Oversampling
	[u]	Undersampling
Examples		R0 = A0 - A1
		R0 = A0 -[o] A1

The Subtraction function subtracts the current point in arg2 from the current point in arg1. The frame characteristics for the function result are determined by the Options. We recommend that the Oversampling option is always used for the Default Option for this function.

Multiplication

arg1 ***** arg2

Options	[o]	Oversampling
	[u]	Undersampling
Examples		R0 = A0 * A1
		R0 = A0 *[o] A1

The Multiplication function multiplies the current point in arg1 by the current point in arg2. The frame characteristics for the function result are determined by the Options. We recommend that the Oversampling option is always used for the Default Option for this function.

Division

arg1 / arg2

Options	[o]	Oversampling
	[u]	Undersampling
Examples		R0 = A0 / A1
		R0 = A0 /[o] A1

The Division function divides the current point in arg1 by the current point in arg2. The frame characteristics for the function result are determined by the Options. We recommend that the Oversampling option is always used for the Default Option for this function.

Power

arg1 ^ arg2

Options	[o]	Oversampling
	[u]	Undersampling
Examples		R0 = A0 ^ A1
		R0 = A0 ^[o] A1

The Power function raises the current point in arg1 to the current point in arg2. The frame characteristics for the function result are determined by the Options. We recommend that the Oversampling option is always used for the Default Option for this function.

Absolute **abs**(arg1)

Example R0 = abs(A0)

If the current point in arg1 is a negative value, the Absolute function converts it to a positive value. Positive values remain unchanged.

Square Root **sqrt**(arg1)

Example R0 = sqrt(A0)

The Square Root function takes the square root of the current point in arg1.

Exponential (Natural Antilog, Base e) **exp**(arg1)

Example R0 = exp(A0)

The Exponential function raises the current point in arg1 to the value *e*.

Logarithm (Base 10) **log**(arg1)

Example R0 = log(A0)

The Logarithm function takes the base 10 logarithm of the current point in arg1.

Natural Log (Base e) **ln**(arg1)

Example R0 = ln(A0)

The Exponential function takes the natural (base *e*) logarithm of the current point in arg1.

Trigonometric Functions

Cosine **cos**(arg1)

Options	[d]	Degrees
	[r]	Radians
	[g]	Grads
Examples		R0 = cos(A0) R0 = cos[r](A0)

The Cosine function takes the cosine of the current point in arg1.

Sine **sin**(arg1)

Options	[d]	Degrees
	[r]	Radians
	[g]	Grads
Examples		R0 = sin(A0) R0 = sin[r](A0)

The Sine function takes the sine of the current point in arg1.

Tangent

tan(arg1)

Options	[d]	Degrees
	[r]	Radians
	[g]	Grads
Examples		R0 = tan(A0) R0 = tan[r](A0)

The Tangent function takes the tangent of the current point in arg1.

ArcCosine

acos(arg1)

Options	[d]	Degrees
	[r]	Radians
	[g]	Grads
Examples		R0 = acos(A0) R0 = acos[r](A0)

The ArcCosine function takes the inverse cosine of the current point in arg1.

ArcSine

asin(arg1)

Options	[d]	Degrees
	[r]	Radians
	[g]	Grads
Examples		R0 = asin(A0) R0 = asin[r](A0)

The ArcSine function takes the inverse sine of the current point in arg1.

ArcTangent

atan(arg1)

Options	[d]	Degrees
	[r]	Radians
	[g]	Grads
Examples		R0 = atan(A0) R0 = atan[r](A0)

The ArcTangent function takes the inverse tangent of the current point in arg1.

Calculus Functions

Differentiation

diff(arg1)

Options		
	[2]	2 Point Method
	[3]	3 Point Method
	[5]	5 Point Method
	[t:1]	1st Order Taylor
	[t:2]	2nd Order Taylor
	[t:4]	4th Order Taylor

Examples

R0 = diff(A0)
R0 = diff[t:2](A0)

The Differentiation function calculates the change between points in arg1 as a function of the x-axis. For the Analysis element, the change is calculated with respect to time ($\frac{d}{dt}$).For the Frequency Analysis element, the change is calculated with respect to frequency ($\frac{d}{df}$). This function requires that arg1 not be a single value.

The available options specify the number of points used to perform the differentiation: the two-point difference [2], the three-point central difference [3], or the five-point polynomial fit [5], or a Taylor differential. The two-point method uses the current and previous data points, and is the closest approximation to an ideal differentiator. The three-point method uses the previous, current, and next data points and the five-point method uses the previous two, current, and next two data points.

The Taylor differential methods are similar to the other methods, with the advantage of additional logic to help reduce end effects (at the beginning and end of the calculation). The order of Taylor differential is expressed as one value less than the number of data points used for the calculation. We recommend using one of the Taylor differential methods in most cases.

Integration

intg(arg1)

Options		
	[r]	Rectangular
	[s]	Simpson's Rule
	[t]	Trapezoidal
	[a:*order*]	Adams-Bashforth (order from 1 to 6)
	[g:*order*]	Gear's (order from 1 to 6)

Examples

R0 = intg(A0)
R0 = intg[a:4](A0)

The Integration function calculates the area under the curve of arg1 with respect to the x-axis. For the Analysis element, the area change is calculated with respect to time ($\int (\arg 1) dt$).For the Frequency Analysis element, the area change is calculated with respect to frequency ($\int (\arg 1) df$). This function requires that arg1 not be a single value.

The available options specify the method used to perform the integration: the Rectangular (or Boxcar), Simpson's, Trapezoidal, Adams-Bashforth, or Gear's method. For the Adams-Bashforth and Gear's method, the order of the method (between 1 and 6) is specified as well. For example, a fourth order Gear's integration would look like this: R0 = intg[g:4](A0).

Y-X Integration

intgyx(arg1, arg2)

Examples
R0 = intgyx(A0, A1)
R0 = intgyx(A0, R0)

The Y- X Integration function is similar to the standard Integration function, except that instead of an integration with respect to time the integration is performed with respect to another channel. This effectively calculates the area under the curve of arg1 with respect to arg2 ($\int (\arg 1) d(\arg 2)$) if the channels were plotted on a Y-X plot. This function requires that both arg1 and arg2 are not single values.

Correlation

corr(arg1, arg2)

Options
[o] Oversampling
[u] Undersampling

Examples
R0 = corr(A0, A1)
R0 = corr[o] (A0, A1)

The Correlation function indicates whether arg1 and arg2 are closely related. This function requires that arg1 not be a single value. The function result has a frame length that is twice as long as the frame length set by the Options. We recommend that the Oversampling option is always used for the Default Option for this function.

When arg1 and arg2 are different channels, the result is called a cross correlation. Note that cross correlation is not commutative; that is corr(arg1, arg2) ≠ corr(arg2, arg1). When arg1 and arg2 are the same channel, the result is an auto correlation.

Correlation values are at their maximum when the second set of data is lagged to most closely match the first set of data, which makes correlation useful in determining the arrival times of signals in noise. If the shape of the signal is known, it can be entered as the second set of data. The lag of the maximum correlation value is most likely the location of the signal in noise. Correlation is often used as an alternative to spectral analysis.

Statistical Functions

Average

avg(arg1)

Example
S0 = avg(A0)

The Average function calculates the arithmetic mean of all points in arg1. The output of the function is a single point, which is produced after all points in arg1 are processed. When used with the Block function, one point is produced for each block of data. When used with the Range function, the average is calculated over the specified range only.

Running Average

ravg(arg1)

Example
R0 = ravg(A0)

The Running Average function calculates the current arithmetic mean based on the current and all previous points in arg1. The output of the function has the same number of points per frame as arg1.

Maximum

max(arg1)

Example S0 = max(A0)

The Maximum function finds the value in arg1 that is closest to +∞. The output of the function is a single point, which is produced after all points in arg1 are processed. When used with the Block function, one point is produced for each block of data.

Running Maximum

rmax(arg1)

Example R0 = rmax(A0)

The Running Maximum function outputs the last point in arg1 that was closest to +∞. If the current point is the new maximum, then the output of the function is equal to the current point, otherwise the output of the function is the previous maximum. The output of the function has the same number of points per frame as arg1.

Minimum

min(arg1)

Example S0 = min(A0)

The Minimum function finds the value in arg1 that is closest to -∞. The output of the function is a single point, which is produced after all points in arg1 are processed. When used with the Block function, one point is produced for each block of data.

Running Minimum

rmin(arg1)

Example R0 = rmin(A0)

The Running Minimum function outputs the last point in arg1 that was closest to -∞. If the current point is the new minimum, then the output of the function is equal to the current point, otherwise the output of the function is the previous minimum. The output of the function has the same number of points per frame as arg1.

Root Mean Square (RMS)

rms(arg1)

Example S0 = rms(A0)

The RMS function finds the root mean square of arg1. The output of the function is a single point, which is produced after all points in arg1 are processed. When used with the Block function, one point is produced for each block of data. When used with the Range function, the root mean square is calculated over the specified range only.

RMS values are often used to measure the effectiveness of a signal in a system, such as the effectiveness in the transfer of power and energy.

Running Root Mean Square

rrms(arg1)

Example R0 = rrms(A0)

The Running RMS function calculates the current root mean square value based on the current and all previous points in arg1. The output of the function has the same number of points per frame as arg1.

Standard Deviation

std(arg1)

Example S0 = std(A0)

The Standard Deviation function finds the deviation from the mean of arg1. The output of the function is a single point, which is produced after all points in arg1 are processed. When used with the Block function, one point is produced for each block of data. When used with the Range function, the standard deviation is calculated over the specified range only.

Standard Deviation is a measure of the variability, or "spread", of the data in a channel. For a normal Gaussian (Bell shape) distribution, the likelihood that any data point will be between the average value plus or minus the value of the Standard Deviation is 68%. Approximately 95% of the values fall within plus or minus two standard deviations. The result is always equal to or greater than zero.

Variance

var(arg1)

Example S0 = var(A0)

The Variance function outputs the square of the standard deviation of arg1. The output of the function is a single point, which is produced after all points in arg1 are processed. When used with the Block function, one point is produced for each block of data. When used with the Range function, the variance is calculated over the specified range only.

Variance is the measure of the dispersion or scattering of a set of values around the mean. While standard deviation is normally used, variance is a more basic mathematical function and is used in the statistical F function.

Logical Functions

All of the logical functions treat data as if it were digital in nature, which means the value can only be 1 (True) or 0 (False). For data that is not digital, the function treats all data values greater than or equal to 1 as a True and all values less than 1 as False.

AND

arg1 **and** arg2

Options	[o]	Oversampling
	[u]	Undersampling
Examples		R0 = A0 and A1
		R0 = A0 and[o] A1

The AND function performs a Boolean AND for the current point in arg1 with the current point in arg2. The frame characteristics for the function result are determined by the Options. We recommend that the Oversampling option is always used for the Default Option for this function.

OR

arg1 **or** arg2

Options	[o]	Oversampling
	[u]	Undersampling
Examples		R0 = A0 or A1
		R0 = A0 or[o] A1

The OR function performs a Boolean OR for the current point in arg1 with the current point in arg2. The frame characteristics for the function result are determined by the Options. We recommend that the Oversampling option is always used for the Default Option for this function.

XOR

arg1 **xor** arg2

Options	[o]	Oversampling
	[u]	Undersampling
Examples		R0 = A0 xor A1
		R0 = A0 xor[o] A1

The XOR function performs a Boolean XOR for the *current* point in arg1 with the *current* point in arg2. The frame characteristics for the function result are determined by the Options. We recommend that the Oversampling option is always used for the Default Option for this function.

NOT

not(arg1)

Example	R0 = not(A0)

The NOT function performs a Boolean NOT for each point in arg1.

Comparison

arg1 ***comparison*** arg2

Options	[o]	Oversampling
	[u]	Undersampling
Examples		R0 = A0 < A1
		R0 = A0 <[o] A1

The Comparison function compares the *current* point in arg1 with the *current* point in arg2 and produces a value of 1 if the comparison is true or a value of 0 is the comparison is false. The frame characteristics for the function result are determined by the Options. We recommend that the Oversampling option is always used for the Default Option for this function.

The valid comparisons are as follows:

Comparison	Syntax	Description
<	arg1 < arg2	Less than
<=	arg1 <= arg2	Less than or equal to
=	arg1 = arg2	Equal to
>=	arg1 >= arg2	Greater than or equal to
>	arg1 > arg2	Greater than
<>	arg1 <> arg2	Not equal to

If..Then..Else

if(arg1,*true_result*,*false_result*)

Example	R0 = if(A0>5,A0,0)
	R0 = if((A0>5) and (A1<2),A0,0)

The If function performs the contents of arg1 and treats it as a Boolean result. If arg1 is equal to 1, the result of the function is the contents of *true_result*. If arg1 is equal to 0, the result of the function is the contents of *false_result.*

Find Event

find(arg1)

Options	[p]	Frame Point Number
	[t]	Frame Time (Analysis) or Frequency (Frequency Analysis)
Examples		S0 = find(A0>5) S0 = find[t](A0>5)

The Find function locates the first data point where the contents of arg1 are satisfied and produces either the point number in the frame or the X-axis location (time or frequency) of the event. The output of the function is a single point. The contents of arg1 will usually be a Comparison or some other function that produces a Boolean result.

Filters

Smoothing Filter

filter(arg1)

Example R0 = filter(A0)

The Smoothing Filter (also called a Hanning filter) function is a simple low-pass (or averaging) smoothing filter. The frequency response of this filter at a frequency f equals $\frac{1+\cos(\frac{2\pi f}{f_{sr}})}{2}$, where f_{sr} is the sample rate of arg1.

FIR Filter

fir[*order, type, f1, f2, window*](arg1)

Delimiters	order	Value between 1 and 400
	type	Frequency response shape
	f1, f2	Corner frequencies
	window	Scaling Window
Example		R0 = fir[10,L,20,R](A0)

The FIR Filter model is a purely digital filter, so it has no analog filter counterpart. FIR filters simulate the impulse response of the filter, which is equal to the inverse Fourier Transform of the filter's frequency response. An FIR filter produces a waveform with a linear phase response, which means that overall shape of the waveform is preserved. There are either four or five parameters (depending on the type) which must be specified for the FIR filter.

The **order** specifies defines the number of filter coefficients used, which affects the slope in the filter's transition bands. The higher the order, the steeper the slope of the filter in the transition band (the range of frequencies between the pass band and stop band frequencies). However, higher filter orders require longer processing time.

The **type** specifies the response type of the filter. This setting also affects if the f2 parameter is used (only Band Pass and Band Reject use the f2 parameter). The available types are as follows:

Type	Syntax	Description
Low Pass	l	Pass frequencies below f1
High Pass	h	Pass frequencies above f1
Band Pass	p	Pass frequencies between f1 and f2
Band Reject	r	Pass frequencies below f1 and above f2

Finally, the **window** specifies the scaling function applied to the incoming data to improve the response of the filter. The window parameter may be omitted, in which case the default window type is used. The available scaling windows are as follows:

Type	Syntax	Description
Hamming	M	For a complete description on scaling windows and the response of each window type, refer to Section 14.3.
Hann	N	
Blackman-Harris	B	
Kaiser-Bessel	K	
Rectangular	R	

IIR Filter **iir[order, type, f1, f2, family, p1, p2]**(arg1)

Delimiters		
	order	Value between 1 and 20
	type	Frequency response shape
	f1, f2	Corner frequencies
	family	IIR filter performance
	p1	Maximum Pass Band Ripple (in Decibels)
	p2	Minimum Stop Band Loss (in Decibels)

Example R0 = iir[3,L,20,E,1,1] (A0)

The IIR Filter model is designed to closely match classic analog filters. As a result, IIR Filters have sharper cutoffs but introduce phase distortion (which means the overall shape of the waveform is altered). FIR filters do not have phase distortion, so the waveform is preserved. There are between five and seven parameters (depending on the type and family) which must be specified for an IIR filter.

The **order** specifies defines the number of filter coefficients used, which affects the slope in the filter's transition bands. For IIR filters, this order value is analogous to the order of an analog filter. The higher the order, the steeper the slope of the filter in the transition band (the range of frequencies between the pass band and stop band frequencies). However, higher filter orders require longer processing time.

The **type** specifies the response type of the filter. This setting also affects if the f2 parameter is used (only Band Pass and Band Reject use the f2 parameter). The available types are as follows:

Type	Syntax	Description
Low Pass	l	Pass frequencies below f1
High Pass	h	Pass frequencies above f1
Band Pass	p	Pass frequencies between f1 and f2
Band Reject	r	Pass frequencies below f1 and above f2

The **family** parameter specifies the characteristic of the IIR filter in the pass band and the stop band. When there is ripple in either the pass band or the stop band, the transition band is much smaller (in other words, the filter has a steeper rolloff). This setting also affects if the p1 and p2 parameters are used to specify the amount of ripple. The available families are as follows:

Family	Syntax	Description
Butterworth	b	Flat pass band, rolloff not as steep
Chebyshev	t	Pass band ripple (p1)
Elliptic	e	Pass band ripple (p1) and stop band loss (p2)
Inverse Chebyshev	i	Stop band loss (p1)

Time Functions

Frame Time

time
time[#points,duration]
time(*pacing_channel*)

Delimiters	#points	Points per frame
	duration	Frame duration in seconds
Examples		R0 = time R0 = time[500,5] R0 = time(A0)

This function should only be used with the Analysis element.

The Time function produces an array of points which are the relative frame time of the result element letter. The result channel must always have frame characteristics (sample rate, points per frame, and duration) already assigned to use the time function without any parameters.

To generate a new point in the result function based on another channel, use the *pacing_channel* parameter. This also assigns the frame characteristics of the pacing channel to the result channel. For example to monitor the frame time of channel A0, the function would be written as time(A0).

If the frame characteristics for the channel have not been set anywhere else, you may use the # points and duration to assign them. Note that this does not produce a paced result (where the data appears in real time) but rather fills the result array as quickly as possible.

Z-Transform (Time or Frequency Shift)

z[*#points*](arg1)

Delimiters	#points	Number of points shifted within the frame (positive or negative shift)
Example		R0 = z[-1](A0)

The Z-Transform, or Shift function, produces an array of points which is identical to the contents of arg1, with the data shifted in the array by the number of points specified by #points. A positive value for #points shifts the data forward in time (or frequency for the Frequency Analysis element), and a negative value for #points shifts the data backward in time (or frequency). For example, use a time shift of -1 to use the previous value of arg1. Any missing data points at the beginning or end of the frame are zero-filled.

Data Ranges

Range

range[*start_at,stop_at*](arg1)

Delimiters	start_at	Starting position of the range function
	stop_at	Ending position of the range function
Options	[p]	Frame Point Number
	[t]	Frame Time (Analysis) or Frequency (Frequency Anaysis)
Examples		R0 = range[1,100](A0) R0 = range[t,1,10](A0)

The Range function performs the contents of arg1 only between the points specified by *start_at* and *stop_at*. This makes it possible to perform a calculation over a subset of the channel data. To accomplish this, the Range function sets all data points outside of the range to 0. Make sure that the *stop_at* point is after the *start_at* point. In addition, the *start_at* point must be greater than 0, and the *stop_at* point must be less than the total number of points in the frame.

If you want to integrate channel A0 from point 100 to point 200, the range function belongs with channel A0. In this case, the equation reads R0=intg(range[100,200](A0)). This equation zeroes out channel A0 outside of the range, then performs the integration on the intermediate result.

When using the Range function, you can receive different results based on where you place the range. Remember that the function zeroes out all data outside of the range. For example, the equation R0=range[100,200](intg(A0)) first integrates channel A0, then zeroes out the data before point 100 and after 200. At point 100, the integration starts at the value of the integration which may not be 0. This is because of precedence order of the equation.

A powerful option is to use the Find Event function to automatically determine the start_at and stop_at parameters based on user-defined conditions. The Find function can be nested directly in the Range arguments or a result channel which uses the Find function to locate an event may be referenced. If data appears to be missing from the Range function after the Find function detects the event, increase the number of points stored in memory using the Options menu, Analysis Settings command, Memory Optimization control.

When a DDE link is used to define the start_at and stop_at parameters, the DDE link should not change while the instrument is running. After the instrument has stopped, the current value in the link is used when a the Display element receives a Retrace command. This makes it easy to use Display cursors to define the range over which a calculation occurs and recalculate the results by hitting the Retrace button.

Hint: If you have a specific function that uses a range frequently, write a user defined function to avoid any confusion about the precedence order of the equation. To create a “range integration function” from the previous examples, try the following function:

Define range_intg(ch, start, stop) = intg (range [start, stop] (ch))

Then you can call the function from the main body of the equation table (for example, R0 = range_intg(A0, 100, 200)).

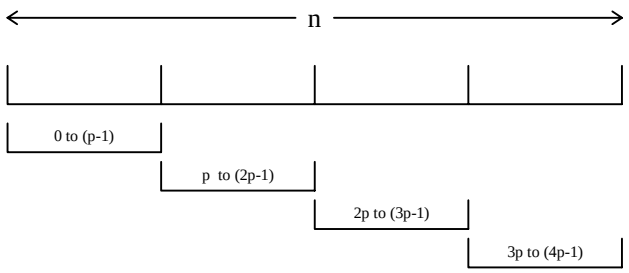
When using the Original syntax, the range is specified directly after a function. The format for using subranges is **'Channel function [option, first point, last point]**. If the function has no options, then the option does not need to be included. For example, the equation 'S0='A0a[100,500] calculates the average of channel A0 between points 100 and 500. To integrate using Gear's 5th order method, the equation would be 'R0='A0i[g:5,100,500].

Block

block[*# points,overlap*](arg1)

Options	[p]	Frame Point Number
	[t]	Frame Time
Examples		R0 = block[5](A0)
		R0 = block[10,2](A0)
		R0 = block[t,1](A0)

The Block function decimates the contents of arg1 by producing the last point in each block of length # points. If arg1 contains a function (such as avg or intg), the argument of that function is decimated. At the beginning of each new block, any equations within arg1 are reset. The optional overlap parameter allows you to perform “Moving” functions by using the same data in subsequent calculations.



The best way to illustrate the Block function is to provide some examples. In the above figure, the total frame length for arg1 is *n* points and the block size for the calculation is *p*. Assume that our equation is R0=block[10](A0) and the frame length is 40 points (numbered from point 0 to point 39). The data from channel A0 is decimated into result channel R0 which contains 4 points (the block size divided into the frame length), and the values of R0 are as follows:

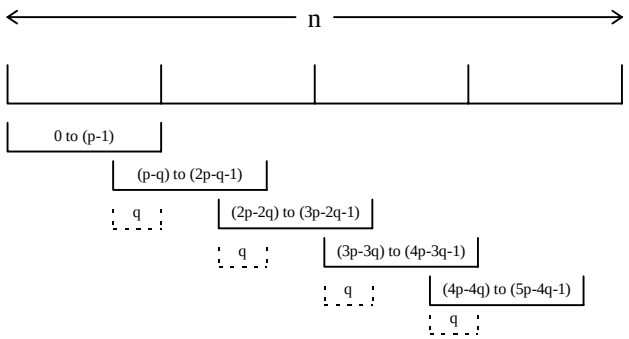
At point #	**R0 equals...**
1	point 9 of channel A0
2	point 19 of channel A0
3	point 29 of channel A0
4	point 39 of channel A0

For another example, assume that our equation is R1=block[10](avg(A0)) and the frame length is 40 points, which effectively decimates and smoothes the data in channel A0. Remember that at the beginning of each block the contents are the argument are reset so the values of R0 are as follows:

At point #	**R0 equals...**
1	the average of points 0-9 of channel A0
2	the average of points 10-19 of channel A0
3	the average of points 20-29 of channel A0
4	the average of points 30-39 of channel A0

Now let's add an overlap of *q* points to the block function. The function is still output at each interval of *p* points, but each calculation after the first looks at the previous *q* points. The start of the interval occurs at each $k(p\text{-}q)$ points (where *k* is the point number of the block result), and the block ends at each $k(p\text{-}q)+(p\text{-}1)$. This means that the number of points advanced for each block is $p\text{-}q$ points.

If there is any data remaining at the end of the frame that does not complete a full interval, the final interval is dropped. Graphically the calculation looks like this:



To illustrate the overlap, let's look at the equation R0=block[10,3](avg(A0)) where the frame length is 40 points. The result channel R0 contains 4 points (the block size divided by the frame length of the argument of average), and the values of R0 are as follows:

At point #	R0 equals...
0	the average of points 0-9 of channel A0
1	the average of points 7-16 of channel A0
2	the average of points 14-23 of channel A0
3	the average of points 21-30 of channel A0
4	the average of points 28-37 of channel A0 (points 38 and 39 are dropped because the final interval is not complete)

Miscellaneous Functions

Fraction

frac(arg1)

Example R0 = frac(A0)

The Fraction function returns the fractional portion for the current point of arg1. The frame characteristics for the function result are determined by arg1.

Modulus

arg1 **mod** arg2

Options [o] Oversampling
[u] Undersampling

Examples R0 = A0 mod A1
R0 = A0 mod[o] A1

The Modulus function returns the remainder portion for the current point of arg1 divided by the current point of arg2. The frame characteristics for the function result are determined by the Options. We recommend that the Oversampling option is always used for the Default Option for this function.

Round

round(arg1)

Example R0 = round(A0)

The Round function returns a whole number where the fractional portion of the current point of arg1 is rounded to the nearest integer. The frame characteristics for the function result are determined by arg1.

Truncate

trunc(arg1)

Example R0 = trunc(A0)

The Truncate function returns the integer portion for the current point of arg1. The frame characteristics for the function result are determined by arg1.

Channel Information

info[*type*](arg1)

Delimiters type A frame characteristic of arg1

Example R0 = info[t](A0)

The Channel Information function returns a constant containing the value of the specified frame characteristic for arg1. DO NOT use the output of the Channel Information function to define the frame characteristics of a result element letter.

For the Analysis element, the available types of information available:

Type	Syntax	Description
Sample Rate	s	Sample rate of arg1
# Points Per Frame	p	Frame duration (in points) of arg1
Total Time Per Frame	t	Frame duration (in seconds) of arg1

For the Frequency Analysis element, the available types of information available:

Type	Syntax	Description
Resolution	s	Resolution of arg1
# Points Per Frame	p	Frame duration (in points) of arg1
Frequency Range	t	Maximum frequency (in Hz) of arg1

Pi **pi**

Example S0 = pi

The Pi function returns a single value of the trigonometric constant π (3.14159265359...).

Pulse **pulse**

Example R0 = pulse

The Pulse function returns an array of points with a value of 1 at the middle point in the frame and 0 elsewhere. This function is often used in conjunction with the FFT element to find the frequency response of a filter or scaling window.

12.3. Equation Syntax

Entries in the equation table fall under one of four categories: equations, references, DDE links, or user defined functions. These are characterized by the following keys:

- Equations start with a result channel (defined using the standard element letter, channel number convention), followed by an equal sign and the equation definition.
- References do not contain an equal sign and are used for frequently used equation fragments or constants. To include a reference in another equation, use the **#** symbol and the line number of the reference.
- DDE links are contained in curly brackets { }, and represent a cold link. DDE links can be used for constant values or to define the start and end points for the Range function. The DDE data can come from a variety of source programs, such as a spreadsheet, user written program, or the Display Cursor Data table.
- User defined functions always start with the keyword **Define** followed by the function name and arguments, an equal sign, and the function definition.

Although it is not required, the text in this manual always capitalizes element letters and uses lower case letters for functions. This is also how the Equation and Function Builders construct equations. We recommend that you use this same form when entering your own equations for improved readability.

Equation Format

The Enhanced Syntax uses an intuitive approach to writing equations. If you are having problems creating an equation, try using the Equation Builder to get started.

Note: These rules apply only when using the Enhanced Syntax option. For information on writing equations using the Original Syntax, please refer to the online help file.

- Equations always begin by defining the result channel, specified as element letter and channel number.
- All result element letters inherit frame characteristics (number of points per frame and duration) based on the function used by the first equation which creates the result element letter.
- The result channel is followed by an equal sign and the calculation being performed.
- Function arguments are always enclosed inside parentheses and appear after the function and any parameters and options. Arguments may contain nested functions.
- Function parameters and options are always enclosed in brackets immediately after the function and before the function arguments. If an options is not specified, the default option (set in the Analysis Options dialog) is used.

User Defined Functions

User defined functions provide an easy way to create your own function for use in the Analysis element equation table. Function definitions look similar to equations, except that:

- User defined functions must appear at the top of the equation table before they are referenced in any equation.
- A user defined function always begins with the keyword **Define**, followed by the name of the function.
- User defined function names and function arguments can only contain alphabetic characters (no numbers allowed) and must not match any of the intrinsic function names built in to the Analysis element.
- After the function name, the arguments for the function are enclosed in parentheses and separated by commas. If the function does not contain any arguments (such as when defining a constant), you must include the parentheses in the function definition.
- The function arguments are followed by an equal sign and the definition of the function. All function arguments must be included in the function definition.

Common Functions

The following is a list of commonly used functions in the Analysis element. Enter these at the top of the equation table before using the function in an equation. (All definitions should be on one line - any line breaks shown here are only to accommodate the size of the page.)

Function	Snap-Master Function Definition

Secant
Cosecant
Cotangent
	`Define sec(x)=1/cos(x)`
	`Define cosec(x)=1/sin(x)`
	`Define cotan(x)=1/tan(x)`

Hyperbolic Sine
Hyperbolic Cosine
Hyperbolic Tangent
	`Define hsin(x)=(exp(x)-exp(-x))/2`
	`Define hcos(x)=(exp(x)+exp(-x))/2`
	`Define htan(x)=(exp(x)-(exp(-x))/exp(x)+ exp(-x))`

Hyperbolic Secant
Hyperbolic Cosecant
Hyperbolic Cotangent
	`Define hsec(x)=2/(exp(x)-exp(-x))`
	`Define hcosec(x)=2/(exp(x)+exp(-x))`
	`Define hcotan(x)=(exp(x)-(exp(-x))/(exp(x)+exp(-x))`

PID (in=input channel, out=output channel)	`Define pid(in,out,P,I,D)=P*(in-out)+I*intg(in-out)+D*diff(in-out)`

12.4. Tutorial: Adding Two Channels

This series of tutorials assume that the has a working knowledge of Snap-Master. In addition to these tutorial sections, there are a number of sample equation files that you may use for reference or to begin customizing your own equations.

All of these tutorials are based on the Analysis element. If you only own the Frequency Analyzer module, you can substitute an FFT element between the A/D Demo element and the Frequency Analysis element to generate frequency domain data to follow along.

Figure 12-9 Instrument for Analysis Tutorials

Building the Instrument

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place the A/D Demo, Analysis, and Display elements in the instrument.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the A/D Demo element to the Analysis element, and the Analysis element to the Display element.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as GAEX1.

The remainder of this tutorial deals with the Analysis element only. If you want to change any of the parameters for the other elements, please refer to the tutorials in the related chapter. The figures shown in this text will be formatted to best illustrate the results of the tutorial.

Building The Equation

1. Open the Analysis element by double clicking on the icon in the instrument window.

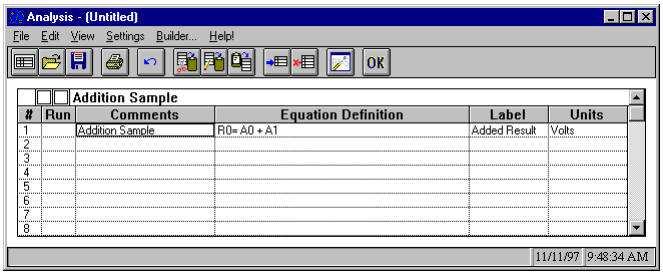

Analysis - (Untitled)
File Edit View Settings Builder... Help!
OK
Addition Sample
Run Comments Equation Definition Label Units
1 Addition Sample R0= A0 + A1 Added Result Volts
11/11/97 9:48:34 AM

Figure 12-10 Analysis Window with Addition Equation

These tutorials concentrate on using the Equation Builder, which is best used with a mouse or other pointing device. If you are only using the keyboard, you can enter the equation directly in the equation table. Position the selection box in the first row, Equation Definition column, type *R0 = A0 + A1*, then press ENTER. To continue the tutorial, skip ahead to Step 14.

2. Press the button or select the Builder menu to open the Equation Builder.

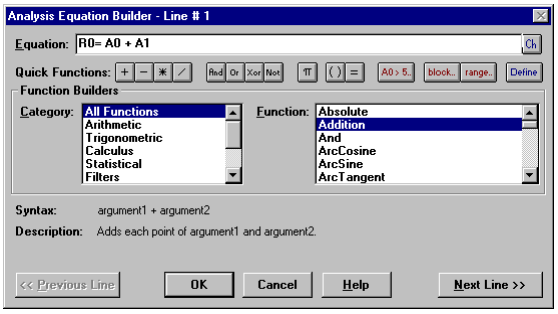

Analysis Equation Builder - Line # 1
Equation: R0= A0 + A1
Quick Functions:
Function Builders
Category: All Functions Arithmetic Trigonometric Calculus Statistical Filters
Function: Absolute Addition And ArcCosine ArcSine ArcTangent
Syntax: argument1 + argument2
Description: Adds each point of argument1 and argument2.
<< Previous Line
OK
Cancel
Help
Next Line >>

Figure 12-11 Equation Builder with Addition Equation

The first item needed in the equation is the result channel. We have two options for entering the channel: either typing it in manually or using the On-Screen Keypad. To illustrate its functionality, these instructions show how to open the On-Screen Keypad and use it to define a channel.

3. Position the mouse pointer over the Equation edit control and press the right mouse button to open the On-Screen Keypad.

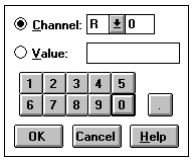


Figure 12-12 On-Screen Keypad

4. Select the Channel radio button.

5. Select the letter R from the list box.

6. Press the number 0 on the On-Screen Keypad.

7. Press the OK button to close the On-Screen Keypad.

8. Click on the = button. The equal sign appears after R0 in the equation line.

The next step is to select the Addition function and use the Function Builder to define or calculation.

9. Double click on the Addition item in the Function list to open the Addition Function Builder.

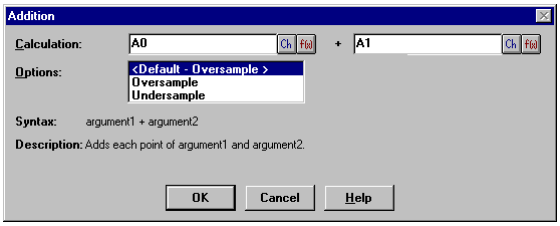


Figure 12-13 Function Builder for Addition

10. For the first argument (on the left side), press the Ch button and click on channel A0.

11. For the second argument (on the right side), press the Ch button and click on channel A1.

This defines the two arguments required for the function. If you forget to fill in both arguments, you will not be allowed to exit the Function Builder using the OK button.

12. Press the OK button to close the Function Builder. When you return to the main Equation Builder, notice that the text "A0 + A1" has been inserted automatically.

13. Press the OK button to close the Equation Builder. When you return to the equation table, the equation is entered in the first row, Equation Definition column.

14. Position the selection box in the first row, Comments column. Using the keyboard, type *Addition Sample*, then press ENTER.

    The Comments column is a place where you can assign enter information about the equation line. These comments are included for your convenience. If this column is not visible, you can turn it on in the Analysis Settings dialog.

15. Position the selection box in the first row, Label column. Using the keyboard, type *Added Result*, then press ENTER.

    The Label column assigns a channel label to each result channel defined in the equation line. When this channel is referenced in this and other elements, the channel label will appear along with the element letter and channel. You can only label result channels with this column.

16. Position the selection box in the first row, Units column. Using the keyboard, type *Volts*, then press ENTER.

    The Units column assigns the units for each result channel defined in the equation line. These units are used by the Display element to define the y-axis units, and are also stored by the Disk Out element when saving the result channel. You can only assign units to result channels with this column.

17. Switch to the main Snap-Master window and save the instrument using the button or the File menu, Save Instrument command.

Running the Instrument

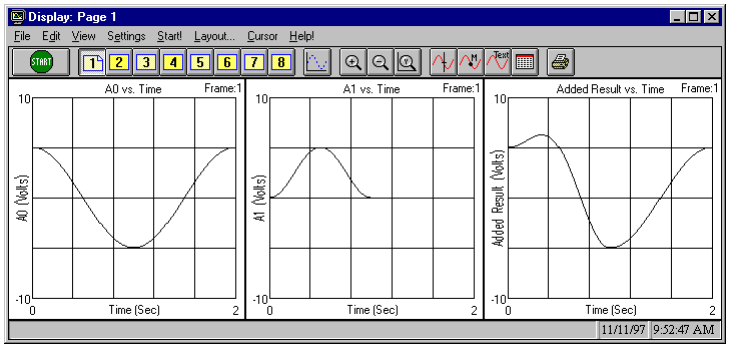


Figure 12-14 Display of Addition Equation Inputs and Result

When you Start the instrument, you should see the results. This Display window shows three Y-T plots, one each for A0, A1, and R0. Notice that the channel label and units are included automatically in the plot of R0.

If you receive a message that says the Analysis equations must be checked before the instrument will run, open the Analysis window and press the button. The button says when the equations are correct.

12.5. Tutorial: Performing A Block Average

This tutorial uses two functions: the Block and Average functions to obtain a new result. By itself, the Average function produces only a single point. By including the Block function, we can obtain an average for each block of points.

Building The Equation

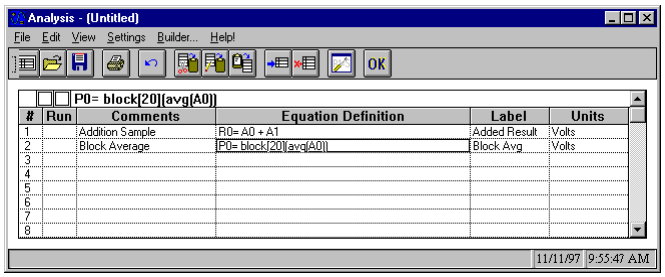

Analysis - (Untitled)
File Edit View Settings Builder... Help!
OK
P0= block[20](avg(A0))
# Run Comments Equation Definition Label Units
1 Addition Sample R0= A0 + A1 Added Result Volts
2 Block Average P0= block[20](avg(A0)) Block Avg Volts
11/11/97 9:55:47 AM

Figure 12-15 Analysis Window with Block Average Equation

1. Position the selection box in the second row of the equation table.

2. Press the button or select the Builder menu to open the Equation Builder.

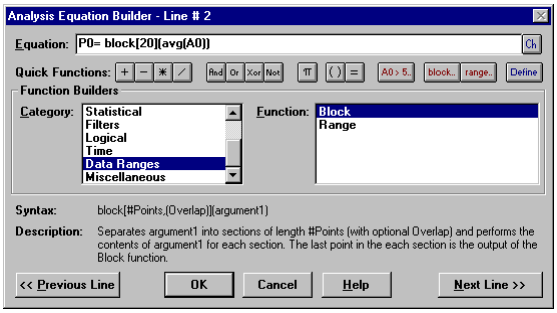

Analysis Equation Builder - Line # 2
Equation: P0= block[20](avg(A0))
Quick Functions:
Function Builders
Category: Statistical Filters Logical Time Data Ranges Miscellaneous
Function: Block Range
Syntax: block(#Points,(Overlap))(argument1)
Description: Separates argument1 into sections of length #Points (with optional Overlap) and performs the contents of argument1 for each section. The last point in the each section is the output of the Block function.
<< Previous Line
OK
Cancel
Help
Next Line >>

Figure 12-16 Equation Builder with Block Average Equation

3. Position the mouse pointer over the Equation edit control and press the right mouse button to open the On-Screen Keypad.

4. Select the Channel radio button.

5. Select the letter P from the list box.

   Because the Block function produces different frame characteristics that our first equation, we will use a different element letter for this result channel.

6. Press the number 0 on the On-Screen Keypad.

7. Press the OK button to close the On-Screen Keypad.

8. Click on the = button.

9. Click on the Data Ranges item in the Category list. This shows the related functions in the Function list.

10. Double click on the Block item in the Function list to open the Block Function Builder.

You may be wondering why the Block function is selected first and not the Average function. The reason is that Snap-Master's equation syntax is designed to work in the same fashion as you think. In general you build the equation exactly as you would speak it - "perform a block average."

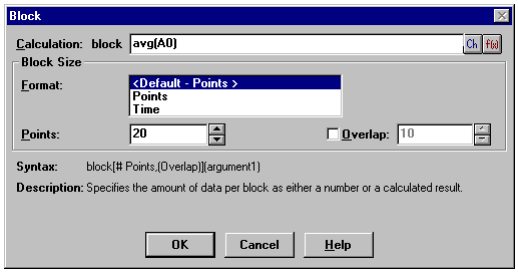


Figure 12-17 Function Builder for Block

Now that we have the Block Function builder open, we need access to the Average Function Builder. It is easy to nest functions in the Equation and Function Builders using the f(x) button.

11. Press the f(x) button, select the Statistical item, Single Value item, and Average item to open the Average Function Builder.

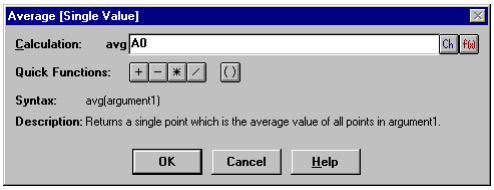

Average [Single Value]
Calculation: avg A0
Quick Functions: + - * / ( )
Syntax: avg(argument1)
Description: Returns a single point which is the average value of all points in argument1.
OK
Cancel
Help

Figure 12-18 Function Builder for Average

12. Press the Ch button and click on channel A0.

This is all we need for the Average function, so we can close it and return to the Block Function Builder and set the number of points per block.

13. Press the OK button to close the Average Function Builder.

14. Change the Points to 20.

15. Press the OK button to close the Block Function Builder and return to the Equation Builder.

16. Press the OK button to close the Equation Builder.

17. Position the selection box in the second row, Comments column. Using the keyboard, type *Block Average*, then press ENTER.

18. Position the selection box in the second row, Label column. Using the keyboard, type *Block Avg*, then press ENTER.

19. Position the selection box in the second row, Units column. Using the keyboard, type *Volts*, then press ENTER.

20. Switch to the main Snap-Master window and save the instrument using the button or the File menu, Save Instrument command.

Running The Instrument

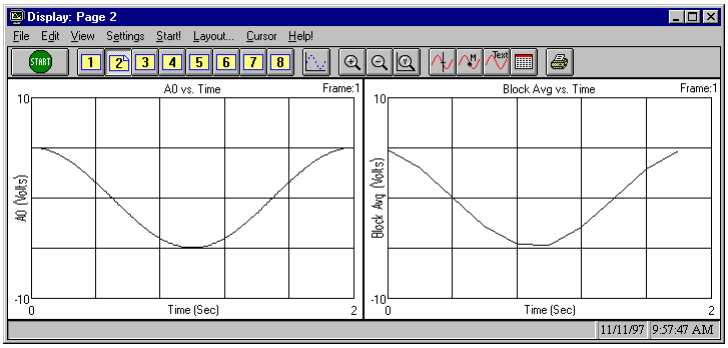


Figure 12-19 Display Window with Input and Block Average Result

When you run the instrument, you should see the results shown in Figure 12-19. This Display window shows two Y-T plots, one for A0, and one for P0.

12.6. Tutorial: Finding When An Event Occurs

There are many instances when it is important to find out not only what the value of an event is, but also when the event occurred. The Find function produces either the point number or the frame time of an event.

Building The Equation

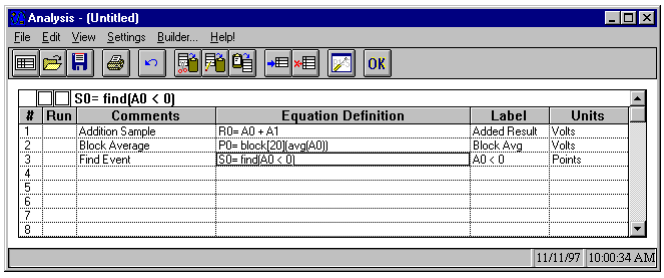

Analysis - (Untitled)
File Edit View Settings Builder... Help!
OK
S0= find(A0 < 0)
# Run Comments Equation Definition Label Units
1 Addition Sample R0= A0 + A1 Added Result Volts
2 Block Average P0= block[20](avg(A0)) Block Avg Volts
3 Find Event S0= find(A0 < 0) A0 < 0 Points
11/11/97 10:00:34 AM

Figure 12-20 Analysis Window with Find Equation

1. Position the selection box in the third row of the equation table.

2. Press the button or select the Builder menu to open the Equation Builder.

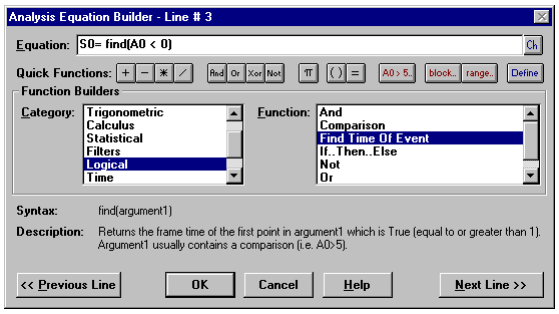


Figure 12-21 Equation Builder with Find Equation

3. Position the mouse pointer over the Equation edit control and press the right mouse button to open the On-Screen Keypad.

4. Select the Channel radio button.

5. Select the letter S from the list box.

The Find function returns a single point, so the frame length of our result is one point. For this reason, we will use a different element letter for this result channel.

6. Press the number 0 on the On-Screen Keypad.

7. Press the OK button to close the On-Screen Keypad.

8. Click on the = button.

9. Select the Logical item in the Category list, then double click on the Find Time of Event item in the Function list to open the Function Builder.

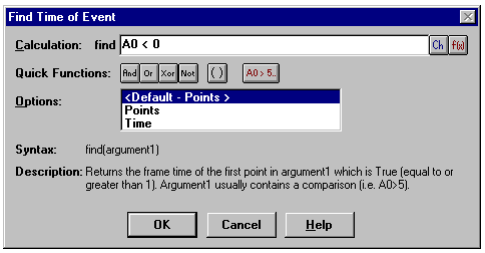

Find Time of Event
Calculation: find A0 < 0
Quick Functions:
Options:
<Default - Points >
Points
Time
Syntax: find(argument1)
Description: Returns the frame time of the first point in argument1 which is True (equal to or greater than 1). Argument1 usually contains a comparison (i.e. A0>5).
OK
Cancel
Help

Figure 12-22 Function Builder for Find Time of Event

Now that we have the Find Function Builder open, we need to define the condition to look for using the Comparison Function Builder.

10. Press the A0 > 5.. button to open the Comparison Function Builder.

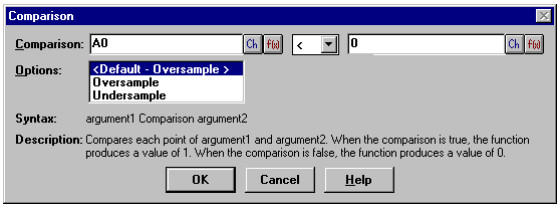


Figure 12-23 Function Builder for Comparison

11. Press the Ch button in the first argument and click on channel A0.

12. Select the "<" item from the combo box.

13. Enter 0 in the second argument edit control.

14. Press the OK button to close the Comparison Function Builder.

15. Press the OK button to close the Find Function Builder and return to the Equation Builder.

16. Press the OK button to close the Equation Builder.

17. Position the selection box in the third row, Comments column. Using the keyboard, type *Find Event*, then press ENTER.

18. Position the selection box in the third row, Label column. Using the keyboard, type *A0 < 0*, then press ENTER.

19. Position the selection box in the third row, Units column. Using the keyboard, type *Points*, then press ENTER.

20. Switch to the main Snap-Master window and save the instrument using the button or the File menu, Save Instrument command.

Running The Instrument

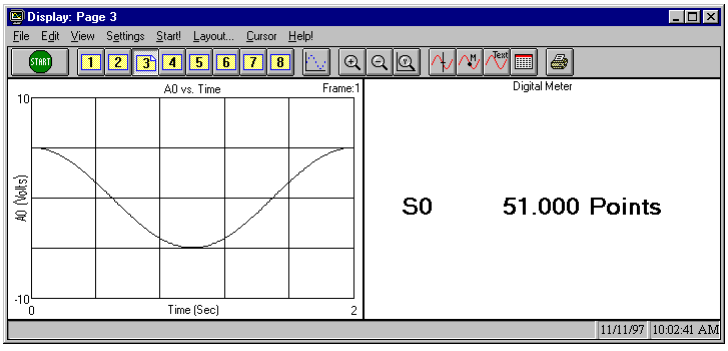


Figure 12-24 Display Window with Find Results

When you Start the instrument, you should see the results shown. This Display window shows a Y-T plot for A0 and a digital meter for S0. You can verify the point number where channel A0 drops below zero using a cursor or marker.

12.7. Tutorial: Integrating Over A Specific Range Of Data

Performing an integration in Snap-Master is a fairly straight forward task. When you combine a function with the Range and Find functions, you can use Snap-Master to intelligently process your data. In this tutorial, we will see how to integrate over a specific range of points, where the range is determined by looking at the incoming data values.

Building The Equation

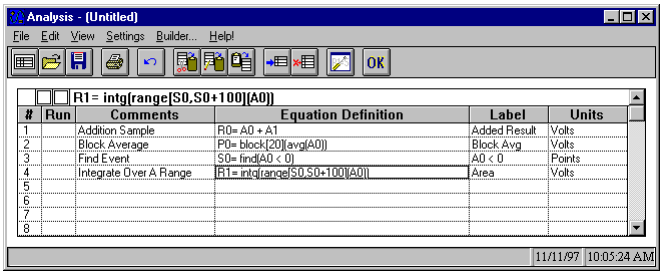

Analysis - (Untitled)
File Edit View Settings Builder... Help!
OK
R1= intg[range[S0,S0+100](A0)]
# Run Comments Equation Definition Label Units
1 Addition Sample R0= A0 + A1 Added Result Volts
2 Block Average P0= block[20](avg(A0)) Block Avg Volts
3 Find Event S0= find(A0 < 0) A0 < 0 Points
4 Integrate Over A Range R1= intg[range[S0,S0+100](A0)] Area Volts
5
6
7
8
11/11/97 10:05:24 AM

Figure 12-25 Analysis Window with Integration Over A Range

1. Position the selection box in the fourth row of the equation table.

2. Press the button or select the Builder menu to open the Equation Builder.

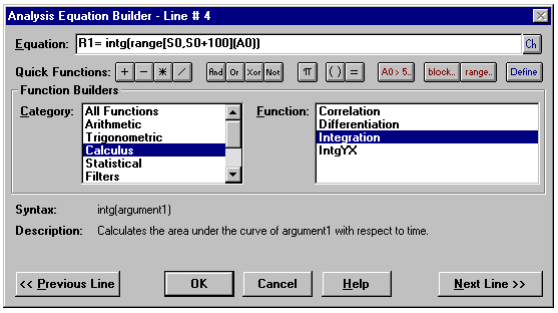

Analysis Equation Builder - Line # 4
Equation: R1= intg[range[S0,S0+100](A0)]
Quick Functions:
Function Builders
Category: All Functions Arithmetic Trigonometric Calculus Statistical Filters
Function: Correlation Differentiation Integration IntgYX
Syntax: intg(argument1)
Description: Calculates the area under the curve of argument1 with respect to time.
<< Previous Line
OK
Cancel
Help
Next Line >>

Figure 12-26 Equation Builder with Integration Over A Range

3. Position the mouse pointer over the Equation edit control and press the right mouse button to open the On-Screen Keypad.

4. Select the Channel radio button.

5. Select the letter R from the list box.

   The Integration function returns an array that has the same frame characteristics of the input function. Because we already have a result channel R0 with these frame characteristics, let's assign a new channel to this element letter.

6. Press the number 1 on the On-Screen Keypad.

7. Press the OK button to close the On-Screen Keypad.

8. Click on the button.

9. Select the Calculus item in the Category list, then double click on the Integration item in the Function list to open the Function Builder.

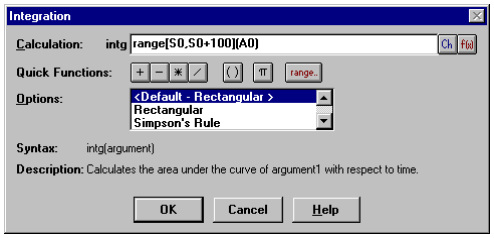


Figure 12-27 Function Builder for Integration

In the Block Average example we first opened the Block function, then the Average. But for this example we are using the Integration function first and then the Range function. Remember that the syntax follows how you would speak the function ("block average," "integrate over a range," etc.).

10. Press the range.. button to open the Range Function Builder.

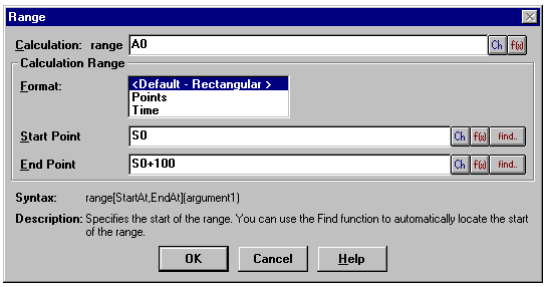


Figure 12-28 Function Builder for Range

11. Press the Ch button in the argument and click on channel A0.

The argument for the Range function is the channel we want to examine. Remember that the Range function sets all data before the Start Point and all data after the End Point to zero. For the Integration function in this example, this means that the integration does not appear to begin until the start point (the integration of zero is zero). If the Range function were put before the Integration, there would be an offset at the start point because the function is looking at a "range of the integration."

12. Press the Ch button in the Start At point and click on channel S0.

In the previous example, we defined channel S0 as the data point where A0 goes below 0. We can use this result for the Range function parameter as if it were a constant. If you already know the point number where you want to begin the range, you could enter that number directly.

13. Press the Ch button in the Stop At point and double click on channel S0, then add *+ 100* after the channel.

    This says that the Range function ends 100 points after A0 is less than 0 (the contents of channel S0). It is possible to enter the Find function directly into the Range parameters using the find.. Quick Function button.

14. Press the OK button to close the Range Function Builder.

15. Press the OK button to close the Integration Function Builder and return to the Equation Builder.

16. Press the OK button to close the Equation Builder.

17. Position the selection box in the fourth row, Comments column. Using the keyboard, type *Integrate Over A Range*, then press ENTER.

18. Position the selection box in the fourth row, Label column. Using the keyboard, type *Area*, then press ENTER.

19. Position the selection box in the fourth row, Units column. Using the keyboard, type *Volts*, then press ENTER.

20. Switch to the main Snap-Master window and save the instrument using the button or the File menu, Save Instrument command.

Running The Instrument

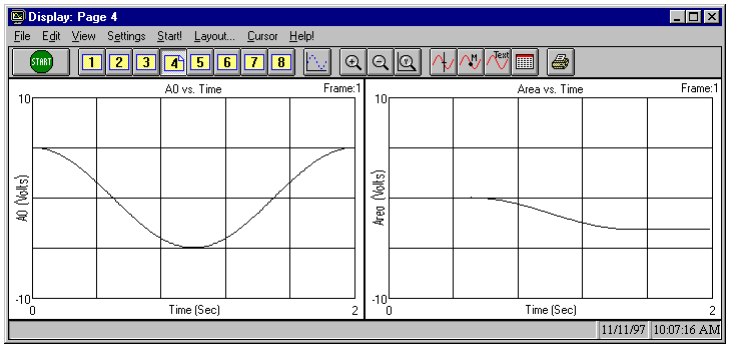


Figure 12-29 Display Window with Integration Over A Range

When you Start the instrument, you should see the results shown. This Display window shows a Y-T plot for A0 and R1. Notice that the integration does not begin until the value of A0 goes below 0 volts and stops 1 second after that (the sample rate for A0 is 100 Hz, so 100 points is equal to 1 second). If you want to see the signal being integrated, use the equation *range[S0, S0+100](A0)*.

12.8. Tutorial: Defining Your Own Functions

When you have an equation that you want to use for multiple channels, you can create a convenient name for the calculation and create a new function for the Analysis element using the Define keyword. We will take the Block Average calculation from a couple of sections back and create a simple function call.

Defining A New Function

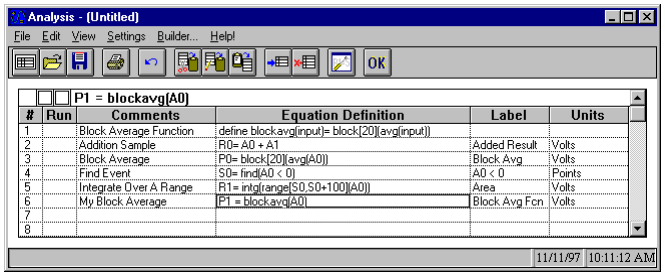

Analysis - (Untitled)
File Edit View Settings Builder... Help!
OK
P1 = blockavg(A0)
# Run Comments Equation Definition Label Units
1 Block Average Function define blockavg(input)= block[20](avg(input))
2 Addition Sample R0= A0 + A1 Added Result Volts
3 Block Average P0= block[20](avg(A0)) Block Avg Volts
4 Find Event S0= find(A0 < 0) A0 < 0 Points
5 Integrate Over A Range R1= intg(range(S0,S0+100)(A0)) Area Volts
6 My Block Average P1 = blockavg(A0) Block Avg Fcn Volts
7
8
11/11/97 10:11:12 AM

Figure 12-30 Analysis Window with User-Defined Function

1. Position the selection box in the first row of the equation table.

2. Insert a new line in the equation table by pressing the button or using the Edit menu, Insert command.

All user defined functions must be located at the top of the equation table.

3. Press the button or select the Builder menu to open the Equation Builder.

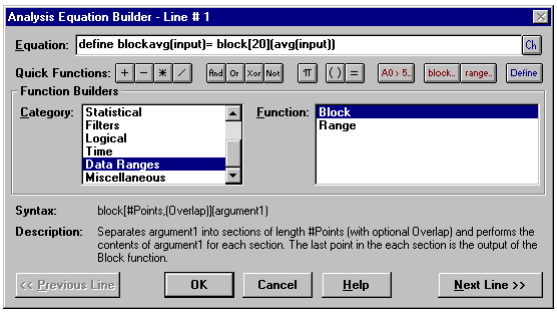

Analysis Equation Builder - Line # 1
Equation: define blockavg(input)= block[20](avg(input))
Ck
Quick Functions: + − * / And Or Xor Not π ( ) = A0 > 5.. block.. range.. Define
Function Builders
Category: Statistical Filters Logical Time Data Ranges Miscellaneous
Function: Block Range
Syntax: block(#Points,(Overlap))(argument1)
Description: Separates argument1 into sections of length #Points (with optional Overlap) and performs the contents of argument1 for each section. The last point in the each section is the output of the Block function.
<< Previous Line
OK
Cancel
Help
Next Line >>

Figure 12-31 Equation Builder with Block Average Function Definition

4. Press the button to insert the keyword in the Equation edit control.

5. Type *blockavg(input)* in the Equation edit control.

6. Click on the button.

7. Click on the Data Ranges item in the Category list, then double click on the Block item in the Function list.

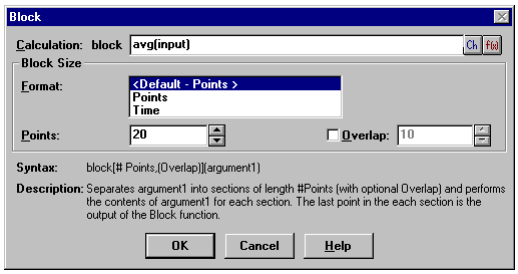

Block
Calculation: block avg(input)
Block Size
Format:
<Default - Points >
Points
Time
Points: 20
Overlap: 10
Syntax: block(# Points,(Overlap))(argument1)
Description: Separates argument1 into sections of length #Points (with optional Overlap) and performs the contents of argument1 for each section. The last point in the each section is the output of the Block function.
OK
Cancel
Help

Figure 12-32 Function Builder for Block

8. Press the f(x) button, select the Statistical item, Single Value item, and Average item to open the Average Function Builder.

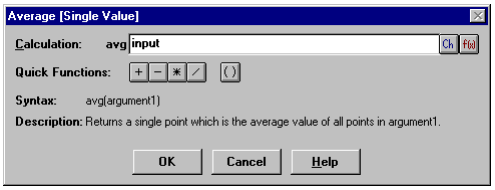

Average [Single Value]
Calculation: avg input
Quick Functions: + - * / ( )
Syntax: avg(argument1)
Description: Returns a single point which is the average value of all points in argument1.
OK
Cancel
Help

Figure 12-33 Function Builder for Average

9. Type *input* as the argument for the Average function.

The function argument in this case is input, which we will supply when we call the function.

10. Press the OK button to close the Average Function Builder.

11. Type 20 in the Points edit control.

12. Press the OK button to close the Block Function Builder and return to the Equation Builder.

13. Press the OK button to close the Equation Builder.

14. Position the selection box in the first row, Comments column. Type *Block Average Function*, then press ENTER.

15. Switch to the main Snap-Master window and save the instrument using the button or the File menu, Save Instrument command.

Calling The Function In An Equation

Now that our function has been defined, we can call it in any other calculation (even other function definitions) just like one of the built-in functions.

1. Position the selection box in the sixth row, Equation Definition column.

2. Using the keyboard, type *P1 = blockavg(A0)*, then press ENTER.

Our function blockavg has one argument, which is the input channel. The syntax looks identical to other functions in Snap-Master which have a single argument. (Note: the Equation Builder is only used for the built-in functions of the Analysis element, so you must type any user-defined functions directly in the equation table.)

3. Position the selection box in the sixth row, Comments column. Type *My Block Average*, then press ENTER.

4. Position the selection box in the second row, Label column. Using the keyboard, type *Block Avg Fcn*, then press ENTER.

5. Position the selection box in the second row, Units column. Using the keyboard, type *Volts*, then press ENTER.

6. Switch to the main Snap-Master window and save the instrument using the button or the File menu, Save Instrument command.

Running the Instrument

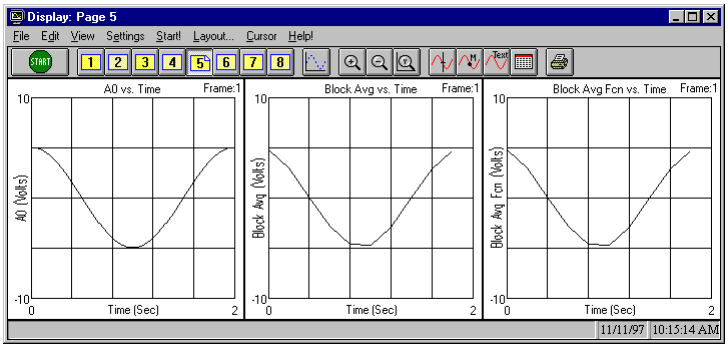


Figure 12-34 Display of Cascaded Equation Results

When you Start the instrument, you should see the results shown. This Display window shows Y-T plots for R0, P0, and P1. The plots for P0 and P1 are identical because they are performing the same calculation.

Chapter 13. Command

13.1. Menu Commands....13-2
13.2. Command Equations....13-3
13.3. Tutorial: Creating A Trigger To Stop....13-9
13.4. Tutorial: Subroutines and State Variables....13-12
13.5. Tutorial: Automatically Starting Another Instrument....13-15

The Command element allows the user to make decisions and perform actions based on data from other Snap-Master elements, such as an A/D Board or the Analysis element. Actions include setting the value of a Digital Out or D/A element channel, starting and stopping instruments, and displaying messages.

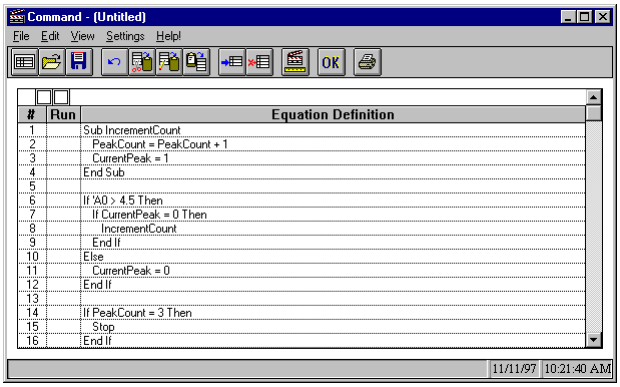


Figure 13-1 Command Element Window

Command Bar

The Command Bar buttons unique to the Command element menu are:

Opens the Command Settings.

Checks the equations for errors. The button says when the table check is successful.

Equation Table Columns

Like the Analysis element, the Command element uses an equation table where all active equations are run. Equations are turned on or off in the Run column. A description for each column is listed below.

Symbol	Description
#	Indicates the line number of the equation. Up to 100 lines of comments or equations can be written.
Run	Indicates if the Equation Definition contains a comment. When the field contains an "X", then the contents of the Equation Definition are not processed.
Equation Definition	Place where the equation statement is defined. Each equation can be approximately 250 characters long.

13.1. Menu Commands

Please refer to Chapter 2 for a description of the common menu commands.

View

Auto Indent When selected, the Command element indents the equation lines based on their position within a nested If loop. This setting does not affect the results.

Auto Case When selected, the Command element automatically capitalizes the equation lines. This setting does not affect the results.

Settings

Command Settings

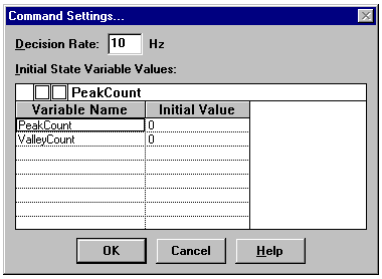


Figure 13-2 Command Settings

Decision Rate — Determines how often the Command element executes the equations in the equation table. Because there is no accompanying Frame Length setting, the Command element is not frame based and treats all data as one continuous frame. The maximum Decision Rate is determined by the overall speed of your computer and the complexity of the equations being processed. Typically, the maximum Decision Rate for the Command element is 100 Hz. In addition, the Decision Rate must be greater than 0.

Initial State Variable Values — Sets the starting value of any state variable in the equation table. State variables are used to keep track of additional data not available from data channels. The default starting value for each state variable is 0, unless set to something else in this table.

13.2. Command Equations

When arranging the contents of the Command equation table, Subroutines always come before the main body of equations. The equation table is arranged as follows:

Description	Equation Table Definitions
Subroutine	Sub SubRoutine1 (statements) End Sub
Subroutine	Sub SubRoutine2 (statements) End Sub

Main Text	If (Condition 1) Then
	(True Action List 1)
	End If
	If (Condition 2) Then
	(True Action List 2)
	Else
	(False Action List 2)
	End If

The basic format for a Command element statement uses the following convention:

```
IF (Comparison) THEN
    (True Action List)
ELSE
    (False Action List)
END IF
```

At a minimum, each statement must contain at least the IF, THEN, and END IF key words; the ELSE keyword is optional. The complete statement can be written either as one line or spread out over multiple lines in the equation table. For example, the following two statements are equivalent:

```
If 'A0 > 6 Then 'B0 = 1 End If

If 'A0 > 6 Then
    'B0 = 1
End If
```

If the logical value of Comparison is True, then the True Action List is processed. If the logical value of Comparison is False and the ELSE key word is included, then the False Action List is processed.

When the time comes for the Command element to make a "decision" (which is determined by the Decision Rate set in the Command Settings dialog box), the equation table is read sequentially from top to bottom. Therefore, the order that you list the conditions directly affects the results of the decisions.

Subroutines

You can group Command statements and actions into a named subroutine at the beginning of the equation table. Subroutines are executed only when they are called by name from the main text or from another subroutine. The format for a subroutine is:

```
Sub SubRoutineName
    (statements)
End Sub
```

Subroutines start with the key word Sub and the single word name of the subroutine. The subroutine name is immediately followed by the condition and / or action list , and ends with the words End Sub. If you are using multiple subroutines, you must end the previous one with an End Sub before declaring a new subroutine.

Result Channels and State Variables

The Command element produces two types of variables: result channels and state variables. Result channels are variables that are used by the Digital Out and D/A element to set the values of digital and analog outputs. State variables are internal to the Command element and cannot be referenced by other elements.

Neither result channels nor state variables can be stored to disk with the Disk Out element. This is because the Command element treats all incoming data as a continuous frame (there is no Frame Duration setting with the Decision Rate in the Command Settings dialog). One exception to this rule is, you can use the Digital Meter plot type of the Display element to display Command element result channels (but not state variables).

A result channel is written with a leading apostrophe, just like the Original Syntax in the Analysis element. The value of a Command result channel can be set to either a constant or the value of another data channel. You can not perform any arithmetic on Command element result channels.

The element letter used for a Command element result channel must be the same as the Command element letter in the instrument. If you try to use a different element letter, an error appears in the equation table.

A state variable is used only within the Command element to store data that is not available from other data channels. State variables do not include the leading apostrophe, which distinguishes them from data channels.

Unlike result channels, you can perform some arithmetic on a state variable in the Command element. The allowed operations are addition (+), subtraction (-), multiplication (*), division (/), and modulus (%) (returns the remainder of the number divided by the divisor). State variables can only be assigned integer values from constants or other state variables.

To initialize the starting value of a state variable, use the Command Settings dialog. If you do not initialize the state variable value, it is automatically set to 0 when the instrument is started.

The following example illustrates the power of using a state variable. Suppose you want to stop the current instrument the fifth time the value of channel A0 exceeds 3 volts. To perform this count, you can use a state variable. The statements would look like the following (assume the initial value of our state variable PeakCount is 0):

```
If PeakCount < 5 AND 'A0 > 3 Then
    PeakCount = PeakCount + 1
Else
    Stop
End If
```

Comparisons

Before executing a series of actions, the IF portion of the statement must be true. The value of the IF statement (which can only be either true or false) is determined using comparative operators. The available operators and their Command element symbol are as follows:

Symbol	Comparison	Description
=	Equals	The left variable has the same value as the right variable.
>	Greater Than	The left variable has a larger value than the right variable.
<	Less Than	The left variable has a lesser value than the right variable.
>=	Greater Than Or Equals	The left variable has a value that is either larger than or the same as the right variable.
<=	Less Than Or Equals	The left variable has a value that is either lesser than or the same as the right variable.
<>	Not Equal To	The left variable has a different value than the right variable.

The following table describes the valid comparison types allowed by the Command element. (Note that the comparison of a Constant to a Constant is a method used to define an IF statement result as always True or always False.)

Variable 1	Variable 2	Example
Channel	Channel	'C1 > 'C3
Channel	Constant	'A0 <= 5
Constant	Constant	3 = 3
State Variable	Constant	Valve1 <> 5
State Variable	State Variable	Valve1 < Valve2

Logical Functions

By combining a series of comparisons together with the AND, OR, and XOR logical operators you can create a complex statement without using multiple layers of IF statements. In addition, the NOT operator can be used to make the statement true when the condition is false.

AND

arg1 **and** arg2

Example

```
If 'A0>40 and 'A1>50 Then
    'D3=1
End If
```

The AND function compares the current point in arg1 with the current point in arg2, producing the following results:

arg1		arg2	Result
False	AND	False	False
False	AND	True	False
True	AND	False	False
True	AND	True	True

OR

arg1 **or** arg2

Example

```
If 'A0>40 or 'A1>50 Then
    'D3=1
End If
```

The OR function compares the current point in arg1 with the current point in arg2, producing the following results:

arg1		arg2	Result
False	OR	False	False
False	OR	True	True
True	OR	False	True
True	OR	True	True

XOR

arg1 **xor** arg2

Example

```
If 'A0>40 xor 'A1>50 Then
    'D3=1
End If
```

The XOR function compares the current point in arg1 with the current point in arg2, producing the following results:

arg1		arg2	Result
False	XOR	False	False
False	XOR	True	True
True	XOR	False	True
True	XOR	True	False

NOT **not** (arg1)

Example

```
If not (‘A0>40) Then
    ‘D3=1
End If
```

The NOT function produces the logical opposite for the comparison of the current point in arg1, producing the following results:

	arg1	Result
NOT	False	True
NOT	True	False

The AND, OR, XOR, and NOT operators can be combined in the same IF statement, such as:

```
If ('C1>40 and 'C2>60) or not('C3>20 xor 'C4<3) Then
    'D3=1
End If
```

Actions

Once the Command element has made a decision, an action is performed based on the decision. The following actions can be executed by the Command element:

Set Result Channel Value

‘result = ‘channel
‘result = constant

Examples

```
If ‘A0>40 Then
    ‘D3 = ‘A0
Else
    ‘D3 = ‘A1
End If
```

```
If ‘A0 > 40 Then
    ‘D3 = 5
Else
    ‘D3 = -5
End If
```

A Command element result channel may be assigned to a digital or analog output channel (with the Digital Out or D/A elements respectively). The element letter for the result channel must be the same as the element letter for the Command element itself.

Set State Variable Value

statevar = value

Example

```
If ‘A0>40 Then
    PeakCount = PeakCount + 1
Else
    PeakCount = PeakCount
End If
```

State variables are used internally to the Command element to keep track of additional information not contained in other data channels. As an action, you can assign a state variable a new constant value, the value of another state variable, or perform a simple math function on a state variable.

Stop Instrument

Stop

Example

```
If 'A0>40 Then
    Stop
End If
```

The Stop command stops all elements except the Command element in the instrument. The Command element continues processing all remaining statements in the equation table. This lets you perform any final actions before the entire instrument stops.

Start Instrument

Start("*instrument*")

Example

```
If 'A0>40 Then
    Start("c:\sm\defuser\stage2.ins")
End If
```

The Start command starts an instrument that is already open in the Snap-Master workspace. The "Instrument" reference uses the instrument's file name, and it must be enclosed by parentheses and quotation marks. You must stop the current instrument using the Stop command before you start another instrument.

Post Error Message

Error("*message text*")

Example

```
If 'A0>40 Then
    Error("Machine 1 Too Hot")
End If
```

The Error command allows you to alert the user of a certain condition or keep track of a test's status. The Error command writes the message text to the Status Log, which adds a time and date stamp to the message. In addition, an Error causes the Status Log to open automatically to alert the user. If the Display element is included in the instrument, turn on the Status Bar to displays all Status Log messages.

Log Status Message

Message("*message text*")

Example

```
If 'A0<=40 Then
    Message("Machine 1 OK")
End If
```

The Message command is similar to the Error command, except that it is not interpreted as an error so the Status Log does not automatically open. Messages are still displayed in the Display element's Status Bar.

DDE Poke Command

DDEPoke("*DDECommandString*")

Example

```
If 'A0>40 Then
   DDEPoke("Snap-Master|test.ins!C:Page,3")
End If
```

The DDE Poke command allows you to send a static DDE string from the Command element to other Snap-Master elements or other programs. Most values sent to a Snap-Master element (such as SampleRate) do not take effect until the instrument is restarted. You can only use a static value for the Value parameter - you may not send out the value of a state variable or Command result channel.

When sending a DDE command string, the format of the string is AppName, followed by a vertical bar (SHIFT + \), the Topic, followed by an exclamation point, and the Item. For more information on sending DDE strings to Snap-Master, refer to Appendix D.

DDE Execute Command

DDEExec(“*DDECommandString*”)

Example

```
If ‘A0>40 Then
    DDEExec(“Snap-Master|test.ins!B:MaximizeDisplay”)
End If
```

The DDE Execute command allows you to send a command to other Snap-Master elements or other programs. Most commands sent to a Snap-Master element (such as FileOpen) do not take effect until the instrument is restarted.

Case Statements

Instead of writing a large number of nested IF..THEN..ELSE statements, you may want to use case statements. Using the SELECT CASE syntax with a state variable as the argument (data channels are not supported as the argument), you can write much simpler Command equations.

The format for a case statement is:

```
Select Case statevar
    Case value1:
        (statements)
    Case value2:
        (statements)
End Select
```

Case statements start with the key words Select Case and the single word name of the state variable. Each case to be tested for starts with the key word Case, along with the value associated with the case, followed by a colon. Any statements for the case are written after the line with the Case key word. The statements for a case are finished when either another Case keyword is encountered, or the complete case statement is completed with the End Select key words. All case statements must be completed by an End Select.

13.3. Tutorial: Creating A Trigger To Stop

The next series of tutorials illustrates how to use the Command element. These tutorials use the A/D Demo element, the Command element, and the Display element. The instrument we will use for these tutorials is shown in Figure 13.3-3.

Figure 13-3 Instrument for Command Element Tutorials

Building the Instrument

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place the A/D Demo, Command, and Display elements in the instrument.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the A/D Demo element to the Command element, and the Command element to the Display element.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as CONDEX1.

Writing A Command Routine

This tutorial displays a message and stops the instrument when the data from channel A0 goes below 0. This will illustrate how to put together a series of actions based on a given condition.

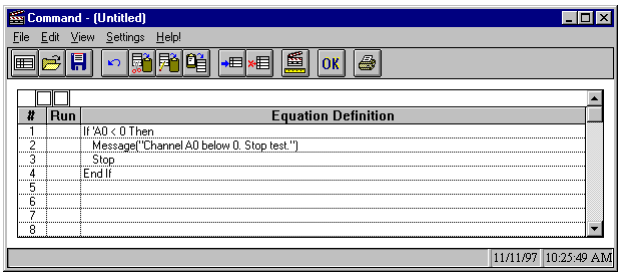


Figure 13-4 Command Element Table Equations

1. Position the selection box in the Equation Definition column of the first row. With the keyboard, type *If 'A0 < 0 Then*, then press ENTER.

> If an arrow appears in the text, do not worry. This means the Auto Check option is turned on and Snap-Master is telling us that we have entered an incomplete statement, which is true. We will finish the statement on the next lines.

2. Position the selection box in the Equation Definition column of the second row. With the keyboard, type *Message("Channel A0 below 0. Stop test.")*, then press ENTER.

3. Position the selection box in the Equation Definition column of the second row. With the keyboard, type *Stop*, then press ENTER.

4. Position the selection box in the Equation Definition column of the second row. With the keyboard, type *End If*, then press ENTER.

> Now that our statement is complete, there should be no errors in the table. If there are, double check the equations.

5. Close the Command equation table using the File menu, Close command.

6. Save the instrument with the button or with the File menu, Save command.

Turning Off Status Messages For The Instrument

In order to get our error message text to appear in the Display window's Status Bar, we need to turn off the Status Messages for the instrument window. This is so the instrument's default messages do not overwrite our own.

1. Open the Instrument Settings dialog with the button or with the Settings menu, Instrument Settings command.

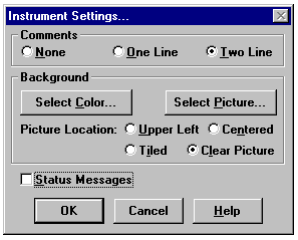


Figure 13-5 Command Element Table Equations

2. Turn off the Status Messages check box.

3. Press the OK button.

4. Save the instrument with the button or with the File menu, Save command.

Running The Instrument

Before we run the instrument, let's clear the Status Log so it will be easier to find our message from the Command element.

1. From the Snap-Master main window, open the Status Log by pressing the button or select the View menu, Show Status Log command.

2. Press the Clear button, then the Exit button.

4. Press the button or the Start menu command.

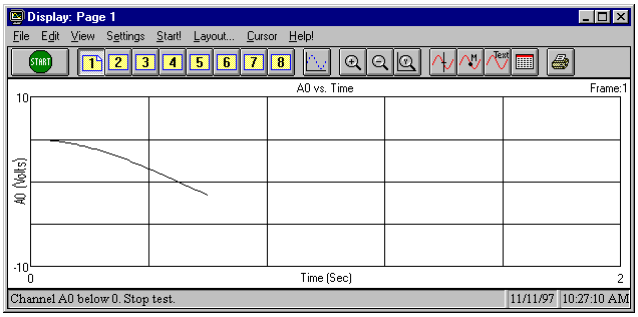


Figure 13-6 Results of Command Element Tutorial

When the instrument is started, the Display (which has been formatted here to show only channel A0) shows that the value of channel A0 starts at 5 volts. When the data value goes below 0 volts, the instrument stops automatically. Note the message in the Display window's Status Bar. If you open the Status Log, you will find the "Channel A0 below 0. Stop test" message we specified.

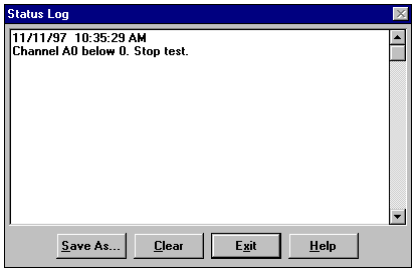


Figure 13-7 Status Log With Message From Command Element

13.4. Tutorial: Subroutines and State Variables

This tutorial illustrates how to use subroutines and state variables. This time, we will process a more complex set of instructions. Our goal is to stop the instrument the third time channel A0 goes above 4.5 volts.

Defining The Equation Table

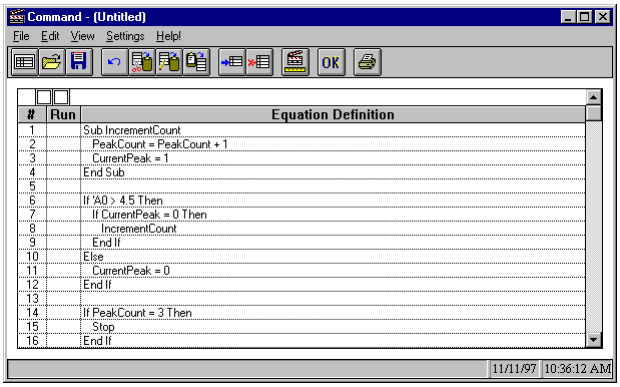


Figure 13-8 Command Equations with Subroutines and State Variables

Before we start the new equations, let's clear the equations from the previous tutorial.

1. In the Command element window, select the File menu, New Equations command.

2. Position the selection box in the Equation Definition column of the first row. With the keyboard, type *Sub IncrementCount*, then press ENTER.

IncrementCount is the name of the subroutine used to add one to the number of peaks encountered in the test. We will call this subroutine later from the main code.

3. In the second row, type the equation *PeakCount = PeakCount + 1*, then press ENTER.

   PeakCount is the state variable used to keep track of the number of times we cross our peak threshold. Because this count value is not contained in any data channel, this is a good use for a state variable.

4. In the third row, type the equation *CurrentPeak = 1*, then press ENTER.

   The CurrentPeak state variable is used to indicate when we are above the peak threshold. If we did not include this variable, then each data point above the threshold would cause the PeakCount to increment. We are using the value of 1 to indicate the waveform is currently above the threshold, and the value of 0 to indicate the waveform is below the threshold.

5. In the fourth row, type *End Sub*, then press ENTER.

   This completes our subroutine. If we wanted to include more subroutines, we would write them next. However, we will continue with the main equations for the Command element.

6. In the sixth row, type the equation *If 'A0 > 4.5 Then*, then press ENTER.

   This statement defines our peak threshold. When channel A0 goes above 4.5 volts, the next set of statements are processed.

7. In the seventh row, type the equation *If CurrentPeak = 0 Then*, then press ENTER.

   Because we only want to increment the count when we are in a new peak, we need to check the value of CurrentPeak. If it is equal to 0 (which means the previous point was below the threshold), we can continue.

8. In the eighth row, type *IncrementCount*, then press ENTER.

   Because the statements have determined that the latest data point has just gone above the peak threshold, we can now increment the value of PeakCount using the IncrementCount subroutine.

9. In the ninth row, type *End If*, then press ENTER.

   This ends the If CurrentPeak = 0 statement.

10. In the tenth row, type *Else*, then press ENTER.

    With this Else statement, we can process a set of statements when the value of channel A0 is less than 4.5 volts.

11. In the eleventh row, type the equation *CurrentPeak = 0*, then press ENTER.

    When the value of channel A0 is less than 4.5 volts, we must set the value of CurrentPeak to 0, which corresponds to our definition of the CurrentPeak state variable.

12. In the twelfth row, type *End If*, then press ENTER.

    We have no more statements for the value of channel A0 and the peak threshold, so the End If terminates that condition statement.

13. In the fourteenth row, type *If PeakCount = 3 Then*, then press ENTER.

    Now we have finally come to the point where we look at the value of the PeakCount state variable to determine if we have reached the maximum number of peaks.

14. In the fifteenth row, type *Stop*, then press ENTER.

    If the value of PeakCount has reached its maximum, then we want to stop the instrument with the Stop action.

15. In the sixteenth row, type *End If*, then press ENTER.

    This closes the If PeakCount = 3 condition statement.

16. Close the Command equation table using the File menu, Close command.

17. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as STATE.

Running The Instrument

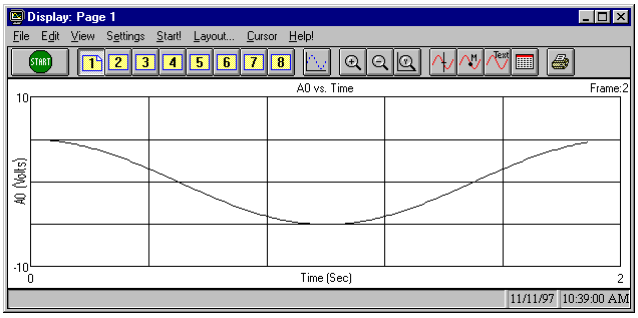


Figure 13-9 Results of Subroutine and State Variable Tutorial

When we Start this instrument, it runs for almost two frames before it stops (note the Frame number in the upper right corner). Our first peak occurs with the first data point because channel A0 starts at 5 volts (which meets our peak condition of 4.5 volts). The second peak occurs at the end of the first frame and spills over into the second frame. The reason the next frame does not cause a new peak condition is because the value of CurrentPeak is still 1. Finally, when the data goes above 4.5 volts towards the end of the second frame, all of our conditions are met and the instrument stops.

13.5. Tutorial: Automatically Starting Another Instrument

This tutorial illustrates how to use the Command element to start another instrument based on certain criteria. This method may be very useful in instances where you want to use one instrument for monitoring purposes and in the event of an error, use another instrument to log data to disk. We will add on to the previous exercise where in addition to stopping the instrument, we will start another instrument.

Building the Second Instrument

Figure 13-10 Instrument for Storing Data Based On A Condition

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place the A/D Demo, Display, and Disk Out elements in the instrument.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the A/D Demo element to the Display element, and the Display element to the Disk Out element.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as CONSTORE.INS.

Updating The Command Routine

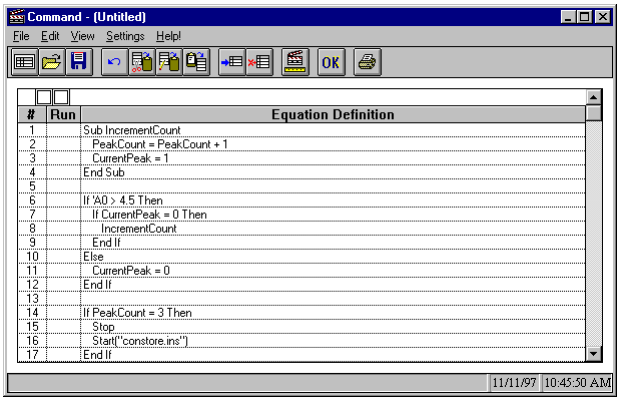


Figure 13-11 Command Equations To Start Another Instrument

1. Move the selection box to row 16, and press the button.

2. In row 16, type *Start("CONSTORE.INS")*, then press ENTER.

   When you want to start another instrument using the Command element, that instrument must already be loaded in the workspace.

3. Switch back to the main Snap-Master window, and save the instrument as CONSTART using the File menu, Save Instrument As command.

Running The Instrument

When you start the CONSTART instrument, you see the same results from our last tutorial. However, when the third peak is found, a new Display window opens, showing us data from the CONSTORE instrument. Remember that by default, the Disk Out element uses the Date & Time file name, so you have a new Standard Binary data file in the DEFUSER subdirectory with the current date and time as the file name.

Chapter 14. FFT

14.1. Menu Commands 14-3
14.2. Functions 14-6
14.3. Window Types 14-11
14.4. Window Width 14-24
14.5. Tutorial: Performing a Forward FFT 14-26
14.6. Tutorial: Performing an Inverse FFT 14-29
14.7. Tutorial: Cross Power Spectrum 14-31
14.8. Tutorial: Transfer and Coherence Functions 14-34

The FFT element converts time domain data to the frequency domain for further analysis, display, and storage. This is accomplished using the Fast Fourier Transform. Besides using the FFT to view the frequency components of a signal, which is used as an alternative to conventional frequency spectrum analysis, the FFT element also includes other complex mathematic functions such as power spectral densities, coherence, transfer, and transmissibility.

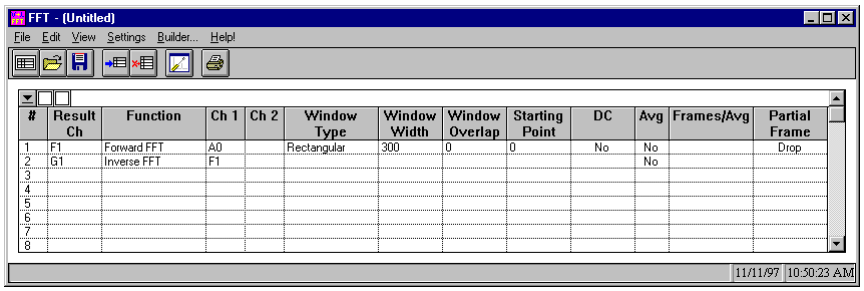

FFT - (Untitled)
File Edit View Settings Builder... Help!
Result Ch Function Ch 1 Ch 2 Window Type Window Width Window Overlap Starting Point DC Avg Frames/Avg Partial Frame
1 F1 Forward FFT A0 Rectangular 300 0 0 No No Drop
2 G1 Inverse FFT F1 No
11/11/97 10:50:23 AM

Figure 14-1 FFT Equation Table

Command Bar

The Command Bar buttons unique to the FFT element are:

Opens the FFT equation builder.

Table Columns

An FFT equation is created by filling in the columns in the FFT equation table, or using the Equation Builder. As in Snap-Master's other tables, the settings for each column are contained in the drop-down list in the upper left corner of the table.

The first step for creating a new FFT equation using the equation table is to create a new result channel by entering a channel number (using the element letter and channel number convention) in the Result Ch column. (Note that the result element letter must not be used by any other Snap-Master elements). Default values are entered in the table for all other settings except the Ch1 and Ch2 columns, which you must fill in using the drop down list.

The following columns are listed in the equation table:

#	Line number for the equation.
Result Ch	The result channel for the frequency domain equation. Each result channel contains an element letter and channel number (such as T0). The element letter must contain only frequency domain data, and each element letter can use only one frequency domain function. When creating a new equation in the table, specify the Result Ch first.
Function	Specifies the frequency domain function to be performed.
Ch 1	Specifies the main channel for the function.
Ch 2	For functions operating on two channels, specifies the second channel. If only one channel is used, this column is not needed.
Window Type	Specifies the window type used in the calculation of the frequency domain function.
Window Width	Specifies the number of points in each window used for the frequency domain calculation. At the end of each window, the FFT element outputs a new frame of data.
Window Overlap	Specifies the number of data points from the previous window used for the beginning of the current window.
Starting Point	Specifies the starting point within a data frame where the function will begin processing. The default starting point is point 0, or the beginning of the frame. This feature is useful for comparing functions on two channels where the event does not begin on the same point.
DC	Specifies if the DC Component (the value of the spectral line at 0 Hz) is kept (“Yes”) or not (“No”).
Avg	Specifies if successive result frames are averaged. The number of frames is set in the Frames / Avg column. Averaging helps lower the amount of noise in the result.
Frames/Avg	If the Avg is set to “Yes,” specifies the number of result frames averaged.
Partial Frame	Specifies if the final result frame uses Zero Extended data or is Dropped. This setting is only used if the number of data points available for the final result frame does not exactly match the window width.

14.1. Menu Commands

Please refer to Chapter 2 for a description of the common menu commands.

Builder

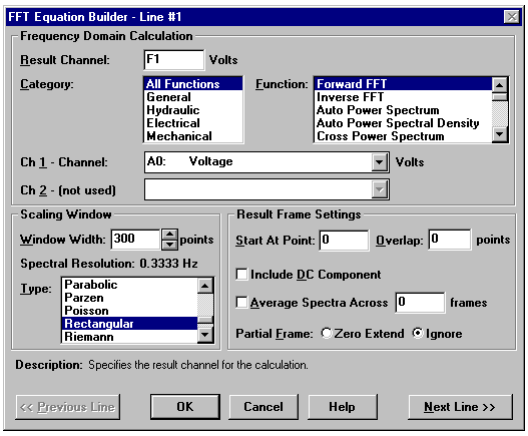

FFT Equation Builder - Line #1
Frequency Domain Calculation
Result Channel: F1 Volts
Category: All Functions General Hydraulic Electrical Mechanical
Function: Forward FFT Inverse FFT Auto Power Spectrum Auto Power Spectral Density Cross Power Spectrum
Ch 1 - Channel: A0: Voltage Volts
Ch 2 - (not used)
Scaling Window
Window Width: 300 points
Spectral Resolution: 0.3333 Hz
Type: Parabolic Parzen Poisson Rectangular Riemann
Result Frame Settings
Start At Point: 0 Overlap: 0 points
Include DC Component
Average Spectra Across 0 frames
Partial Frame: Zero Extend Ignore
Description: Specifies the result channel for the calculation.
<< Previous Line
OK
Cancel
Help
Next Line >>

Figure 14-2 FFT Equation Builder

The FFT Equation Builder provides a convenient way to create and edit the contents of the FFT equation table. All of the available functions, channels, and window types are listed right in the builder. All rules that apply to the corresponding table entry also apply to the Equation Builder.

Frequency Domain Calculation

Result Channel — Specifies the channel number of the result. This field is required.

Category — Select a specific category for the Function list from a variety of engineering disciplines.

Function — Select a frequency domain function for the result channel. The individual functions are discussed later in this chapter.

Ch1
Ch2 — Depending on the selected Function, determines the numerator and denominator for the calculation.

Scaling Window

Window Width — Specifies the number of points used for the calculation. When you leave the text field, the Equation Builder checks to make sure the width is valid. If it is not, a dialog appears asking you to select a valid window width. Alternatively, use the spin buttons to the right of the text field to scroll through the valid window widths.

Spectral Resolution — Indicates the frequency separation of each spectral line in the result calculation. The resolution is determined by the window width and the sample rate of Ch1 and Ch2.

Type — Select a scaling window for the calculation. The individual windows are discussed later in this chapter.

Result Frame Settings

Start At Point

Determines the first time domain point evaluated by the FFT function. This feature is helpful when analyzing an event that does not start at the beginning of a frame or when aligning two separate events.

Changing the starting point may affect both the magnitude response and phase response of the data. This is because in the frequency domain, shifting a waveform in time changes the real and imaginary parts of the frequency domain result in such a manner that the magnitude remains constant, but the ratio of the imaginary part to the real part varies. It is this change in ratio that affects the phase of the result.

Overlap

Determines the number of data points from the previous window used in the current window. For example, if a value of 100 is specified, then the last 100 points used for the previous FFT result frame are used as the first 100 points of the current FFT result frame. The default value for the Window Overlap is zero points.

Remove DC Component

Determines if the spectral line at 0 Hz is included in the result. The DC Component is often removed when it is large in comparison to the remainder of the frequency spectrum. Removing the 0th spectral line is equivalent to subtracting the average of all data in the window while in the time domain.

If you perform a Forward FFT and later plan to perform an Inverse FFT on the data, removing the DC Component will cause the Inverse FFT to present the data centered around 0. The DC option is not available for the Inverse FFT function.

Average Spectra Across Frames

Determines if successive FFT result frames are averaged and the number of frames averaged. Averaging is used to lower the noise margin by minimizing random noise between result frames. If the number of frames averaged is larger than the number of FFT result frames produced by a time domain data frame, the window averaging function averages frequency data across different time-based data frames. To average all frequency result frames within a time domain data frame, enter *0* or *A* in the Frames/Avg column so the entry is "Auto."

For example, assume you are performing a Forward FFT on one time frame with 1000 points, using a window width of 250 points, Window Averaging is turned on, and Frames/Avg is set to 4. The FFT element result will output four frames of data, or one for each window width within the frame (number of windows = window width / number of points per frame). The first frequency frame has the FFT of the first 250 points, the second frequency frame is the average of the FFT of the second 250 points with the first frequency frame, the third frequency frame is the average of the third 250 points with the second frequency frame, etc.

If the waveforms you are analyzing are not periodic within the window, phase differences can cause averaging to decrease. This is because the Forward FFT has both a real and imaginary part (from complex algebra), and the magnitude of the data depends on both parts. Therefore, Averaging should be set to No when the window width does not exactly equal the period of the analyzed waveform.

Window averaging is available only for the Forward FFT function. For all other functions, the Avg column is disabled, but the Yes or No in the column reflects the operation of the function. If averaging is used in the calculation of the function then the Avg column setting is Yes, and if no averaging is used the setting is No.

Partial Frame

Specifies how to handle incomplete data frames for the FFT calculation. **Zero Extend** appends a value of zero for the remaining points in the window width, then performs the frequency domain calculation. Zero extending the data could adversely affect the outcome, by adding artificial data. The **Ignore** option ignore the extra points when the last FFT window does not a complete set of time domain data.

Settings

Noise Floor

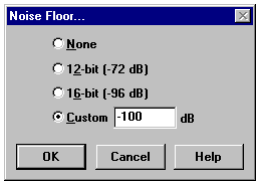


Figure 14-3 Noise Floor Settings

The Noise Floor settings gives you an easy way to clean up the output of the FFT element by specifying the dynamic range of your signals. When **None** is selected, the raw output of the FFT results are presented to elements downstream. The **12-bit (-72 dB)**, **16-bit (-96 dB)**, and **Custom** settings have an associated noise floor specified in decibels. Any signal whose magnitude is below the noise floor setting has both its magnitude and phase set to 0.

14.2. Functions

Summary

The following reference list shows the functions available in the FFT element, grouped by engineering discipline. The Function column determines the frequency domain operation performed on the channels listed in the Ch1 and Ch2 columns. For functions that operate on two channels, the two channels being analyzed must have the same frame characteristics (sample rate, number of points per frame, and frame duration). Snap-Master will not allow you to select channels for these functions that do not have the same characteristics.

General

Function	Numerator Ch 1	Denominator Ch 2
Forward FFT	Channel	
Inverse FFT	Channel	
Auto Power Spectrum	Channel	
Auto Power Spectral Density	Channel	
Cross Power Spectrum	Channel 1	Channel 2
Cross Power Spectral Density	Channel 1	Channel 2
Coherence	Output	Input
Coherent Output Power	Output	Input
Transfer Function	Output	Input

Hydraulic

Function	Numerator Ch 1	Denominator Ch 2	Example Units
Compliance	Flow	Pressure	gpm / psi
Impedance	Pressure	Flow	psi / gpm
Dynamic Compressibility	Volume	Pressure	gallon / psi
Bulk Modulus	Pressure	Volume	psi / gallon

Electrical

Function	Numerator Ch 1	Denominator Ch 2	Example Units
Admittance	Current	Voltage	amp /volt
Impedance	Voltage	Current	volt / amp

Mechanical

Function	Numerator Ch 1	Denominator Ch 2	Example Units
Compliance	Displacement	Force	in / lb
Dynamic Flexibility	Displacement	Force	in / lb
Mobility	Velocity	Force	(in/sec) / lb
Dynamic Accelerance	Acceleration	Force	$(in/sec)^2$ / lb
Dynamic Stiffness	Force	Displacement	lb / in
Impedance	Force	Velocity	lb / (in/sec)
Transmissibility	Force	Velocity	lb / (in/sec)
Dynamic Inertia	Force	Acceleration	lb / $(in/sec)^2$

Forward FFT

A Forward FFT converts time domain data to the frequency domain to determine the Fourier (sinusoidal) components of the signal. Conceptually, the FFT passes the signal through many band-pass filters (one for each frequency), and examines the magnitude and phase of the output signal. The results are then presented with respect to frequency.

Inverse FFT

The Inverse FFT converts frequency domain data to the time domain. The inverse of the FFT is the equivalent of an all-pass filter. Due to the nature of the FFT and the windowing technique, the inverse FFT may not be the exact time-domain function that generated the FFT in the first place. If a window type other than Rectangular is used, the result of the Inverse FFT is the original waveform modulated by the scaling window.

Auto Power Spectrum

The Auto Power Spectrum function calculates the average power in each frequency band of a single channel (Ch1) from the instantaneous amplitude spectrum output by the FFT algorithm. Ch2 is not used for this function. The result units are the square of the input units, such as volts^2 or psi^2.

The Auto Power Spectrum differs from the Auto Power Spectral Density, which is normalized based on the bandwidth of the window type. The Auto Power Spectrum function should be used with signals that have little or no noise and are coherent signals to avoid any effects from the normalization procedure.

Note that the Auto Power Spectrum in the frequency domain is equivalent to a Circular Auto Correlation. However, the correlation function in the Analysis element is a zero-padded, linear correlation. Therefore, the inverse FFT of the power spectrum of a signal will not equal the auto correlation of that signal as calculated by the Analysis element.

The mathematical description for the Auto Power Spectrum is $S_{aa} = avg(S_a S_a^*)$, where a is the channel listed in the Ch1 column, S_a is the instantaneous amplitude spectrum of a, and the S_a^* term is the complex conjugate of S_a.

Auto Power Spectral Density

The Auto Power Spectral Density function calculates the normalized power of a single channel (Ch1) from the instantaneous amplitude spectrum output by the FFT algorithm. Ch2 is not used for this function. The result units are the square of the input units over Hertz, such as volts^2/Hz or psi^2/Hz.

This function is similar to the Auto Power Spectrum, except that the Auto Power Spectrum is "normalized" to make the measurement independent of the sampling rate and window bandwidth. The difference between the Auto Power Spectral Density and the Auto Power Spectrum is that the spectral density is calculated per Hertz.

The normalization of the Auto Power Spectrum takes into account the effective bandwidth of window function used to compute the FFT. By multiplying the spectral values by the inverse of the window period, then the power spectrum is normalized to a per unit bandwidth. This makes the measurements independent of the sample rate and window bandwidth. Normalization is most useful for signals with strong sinusoidal components and random noise.

The mathematical description for the Auto Power Spectral Density is $G_{aa} = \frac{avg(S_a S_a^*)}{df}$, where G is the instantaneous amplitude spectral density, a is the channel listed in the Ch1 column, S_a is the instantaneous amplitude spectrum of a, S_a^* is the complex conjugate of S_a, and df is the frequency resolution.

Cross Power Spectrum

The Cross Power Spectrum determines the average power common to two signals (which are listed in the Ch1 and Ch2 columns). This function is identical to the Auto Power Spectrum. In order to perform the Cross Power Spectrum function, the two channels being analyzed must have the same frame characteristics. The result units are the products of the units, such as volts^2 or (volts * psi).

This function is identical to the Auto Power Spectrum, except that two different channels are used to calculate the amount of power common to both channels. If the same channels are specified in Ch1 and Ch2, then the Cross Power Spectrum is equal to the Auto Power Spectrum of the channel. The Cross Power Spectrum is the frequency domain equivalent of Circular Cross Correlation in the time domain.

The mathematical description for the Cross Power Spectrum is $S_{ba} = avg(S_b S_a^*)$, where b (the output) is the channel listed in the Ch1 column, a (the input) is the channel listed in the Ch2 column, S_b is the instantaneous amplitude spectrum of b, and S_a^* is the complex conjugate of the instantaneous amplitude spectrum of a.

Cross Power Spectral Density

The Cross Power Spectral Density function calculates the normalized power contained in two channels (specified in the Ch1 and Ch2 columns) from the instantaneous amplitude spectrum output by the FFT algorithm. In order to perform the Cross Power Spectral Density function, the two channels being analyzed must have the same frame characteristics. The result units are the products of the units divided by Hertz, such as volts^2/Hz or (volts * psi)/Hz.

This function is similar to the Auto Power Spectral Density, except that two different channels are used to calculate the power common to both channels. If the same channels are specified in Ch1 and Ch2, then the Cross Power Spectral Density is equal to the Auto Power Spectral Density of the channel.

The mathematical description for the Cross Power Spectral Density is $G_{ab} = \frac{avg(S_b S_a^*)}{df}$,

where b (the output) is the channel listed in the Ch1 column, a (the input) is the channel listed in the Ch2 column, G is the instantaneous amplitude spectral density, S_b is the instantaneous amplitude spectrum of b, S_a^* is the complex conjugate of the instantaneous amplitude spectrum of a, and df is the frequency resolution.

Coherence Function

The Coherence function measures the ratio of how much power in the output signal (listed in the Ch1 column) is caused by (or related to) the input signal (listed in the Ch2 column). In order to perform the Coherence function, the two channels must have the same frame characteristics. This function helps to determine whether or not a system is linear at a given frequency. Because the function produces a ratio, the result has no units.

The Coherence function is used to characterize a system or device under test by comparing two channels such as input and output, or maybe two related parameters like voltage and current, or pressure and flow. This helps to determine the efficiency of a system, whether a system is linear, and whether there are extraneous inputs to the system. The coherence function is important because it is a way of validating the quality of the transfer function at each frequency.

The Coherence results are usually averaged over multiple FFT result frames to obtain an accurate representation of the signal. A Coherence value of 1 means that all of the output signal's power comes from the input, while a value less than 1 means that there are other sources for the output power (such as noise). If the Coherence value is 0, then the input signal contributes none of the power to the output signal. In addition, if both the output and input equal 0, then the result is defined as 1. If only the input equals 0 and the output is non-zero, then the Coherence is defined as 0.

The mathematical description for the Coherence function is $COH = \frac{G_{ab}G_{ab}^{*}}{G_{aa}G_{bb}}$, where b (the output) is the channel listed in the Ch1 column, a (the input) is the channel listed in the Ch2 column, G_{ab} is the Cross Power Spectral Density of a and b, G_{ab}^{*} is the complex conjugate of G_{ab}, G_{aa} is the Auto Power Spectral Density of a, and G_{bb} is the Auto Power Spectral Density of b.

Coherent Output Power

The Coherent Output Power function produces a specialized power spectrum that reports how much of the power in the output signal (listed in the Ch1 column) is caused by the input signal (listed in the Ch2 column). The two channels being analyzed must have the same frame characteristics. The result units are the output units squared over the input units, such as volts^2/volt or psi^2/lb.

By definition, if the output and input both equal 0, then the result is also 0. If the input is 0 and the output is non-zero, then the result is infinite, which is defined as 10^{20} by Snap-Master. This Coherent Output Power is different from the Auto Power Spectrum, which produces the power spectrum of the output without regard to the input source.

The mathematical description for the Coherent Output Power function is $COP = \frac{G_{ab}G_{ab}^{*}}{G_{aa}}$, where b (the output) is the channel listed in the Ch1 column, a (the input) is the channel listed in the Ch2 column, G_{ab} is the Cross Power Spectral Density of a and b, G_{ab}^{*} is the complex conjugate of G_{ab}, and G_{aa} is the Auto Power Spectral Density of a.

Transfer Function

The Transfer function represents the frequency response of a system with an output (Ch1) and an input (Ch2). The magnitude and phase response ratios comprise a complete frequency domain representation of the system. In order to perform a Transfer Function, the two channels being analyzed must have the same frame characteristics. The result units are the output units over the input units, such as volts/volt or psi/lb.

The Transfer function H is different from the Coherence function because it represents the response of the system instead of the ratio of inputs to outputs. By definition, when the output and input both equal 0, then the result is also 0. If the input is 0 and the output is non-zero, then the result is infinite, which is defined as 10^{20} by Snap-Master.

The mathematical description of the Transfer function is $H_{ab} = \frac{G_{ab}}{G_{aa}}$, where b (the output) is the channel listed in the Ch1 column, a (the input) is the channel listed in the Ch2 column, G_{ab} is the Cross Power Spectral Density of a and b, and G_{aa} is the Auto Power Spectral Density of a.

Compliance

Compliance is a special transfer function used in both hydraulic and mechanical systems. In order to use this function, the two input channels must have the same frame characteristics.

For hydraulic systems, the numerator (Ch1) of the calculation is a signal measuring flow and the denominator (Ch2) is a signal measuring pressure. The result units are units for flow over the units for pressure, such as gpm/psi. Compliance is the inverse of Impedance.

For mechanical systems, the numerator (Ch1) of the calculation is a signal measuring displacement and the denominator (Ch2) is a signal measuring force. The result units are units for displacement over the units for force, such as in/lb. The Compliance function is equivalent to Dynamic Flexibility, and is the inverse of Dynamic Stiffness.

Impedance

Impedance is a special transfer function used in hydraulic, electrical, and mechanical systems. In order to use this function, the two input channels must have the same frame characteristics.

For hydraulic systems, the numerator (Ch1) of the calculation is a signal measuring pressure and the denominator (Ch2) is a signal measuring flow. The result units are units for pressure over the units for flow, such as psi/gpm. Impedance is the inverse of Compliance.

For electrical systems, the numerator (Ch1) of the calculation is a voltage signal and the denominator (Ch2) is a current signal. The result units are volt/amps. Impedance is the inverse of Admittance.

For mechanical systems, the numerator (Ch1) of the calculation is a signal measuring force and the denominator (Ch2) is a signal measuring velocity. The result units are units for force over the units for velocity, such as lb/(in/sec). The Impedance function is equivalent to Transmissibility, and is the inverse of Mobility. Generally, Impedance is used for parallel combinations of interconnected mechanical elements.

Dynamic Compressibility

Dynamic Compressibility is a special transfer function used in hydraulic systems. In order to use this function, the two input channels must have the same frame characteristics. The numerator (Ch1) of the calculation is a signal measuring volume and the denominator (Ch2) is a signal measuring pressure. The result units are units for volume over the units for pressure, such as gallons/psi. Dynamic Compressibility is the inverse of Bulk Modulus.

Bulk Modulus

Bulk Modulus is a special transfer function used in hydraulic systems. In order to use this function, the two input channels must have the same frame characteristics. The numerator (Ch1) of the calculation is a signal measuring pressure and the denominator (Ch2) is a signal measuring volume. The result units are units for pressure over the units for volume, such as psi/gallons. Bulk Modulus is the inverse of Dynamic Compressibility.

Admittance

Admittance is a special transfer function used in electrical systems. In order to use this function, the two input channels must have the same frame characteristics. The numerator (Ch1) of the calculation is a current signal and the denominator (Ch2) is a voltage signal. The result units are amps/volt. Admittance is the inverse of Impedance.

Dynamic Flexibility

Dynamic Flexibility is a special transfer function used in mechanical systems. In order to use this function, the two input channels must have the same frame characteristics. The numerator (Ch1) of the calculation is a signal measuring displacement and the denominator (Ch2) is a signal measuring force. The result units are units for displacement over the units for force, such as in/lb. The Dynamic Flexibility function is equivalent to Compliance, and is the inverse of Dynamic Stiffness.

Mobility

Mobility is a special transfer function used in mechanical systems. In order to use this function, the two input channels must have the same frame characteristics. The numerator (Ch1) of the calculation is a signal measuring velocity and the denominator (Ch2) is a signal measuring force. The result units are units for velocity over the units for force, such as (in/sec)/lb. The Mobility function is the inverse of Impedance. Generally, Mobility is used for series combinations of interconnected mechanical elements.

Dynamic Accelerance

Dynamic Accelerance is a special transfer function used in mechanical systems. In order to use this function, the two input channels must have the same frame characteristics. The numerator (Ch1) of the calculation is a signal measuring acceleration and the denominator (Ch2) is a signal measuring force. The result units are units for acceleration over the units for force, such as $(in/sec)^2/lb$. Dynamic Accelerance is the inverse of Dynamic Inertia.

Dynamic Stiffness

Dynamic Stiffness is a special transfer function used in mechanical systems. In order to use this function, the two input channels must have the same frame characteristics. The numerator (Ch1) of the calculation is a signal measuring force and the denominator (Ch2) is a signal measuring displacement. The result units are units for acceleration over the units for force, such as lb/in. Dynamic Stiffness is the inverse of Dynamic Flexibility.

Transmissibility

Transmissibility is a special transfer function used in mechanical systems. In order to use this function, the two input channels must have the same frame characteristics. The numerator (Ch1) of the calculation is a signal measuring force and the denominator (Ch2) is a signal measuring velocity. The result units are units for force over the units for velocity, such as lb/(in/sec). The Transmissibility function is equivalent to Impedance, and is the inverse of Mobility.

Transmissibility is often used in vibration isolation and other dynamic systems. There are two types of transmissibility functions: force and motion. For a linear system, these two functions are identical.

Dynamic Inertia

Dynamic Inertia is a special transfer function used in mechanical systems. In order to use this function, the two input channels must have the same frame characteristics. The numerator (Ch1) of the calculation is a signal measuring force and the denominator (Ch2) is a signal measuring acceleration. The result units are units for force over the units for velocity, such as $lb/(in/sec)^2$. Dynamic Inertia is the inverse of Dynamic Accelerance.

14.3. Window Types

Before proceeding into the inner workings of the FFT element, it is important to keep in mind the differences between the analog Fourier Transform and the discrete Fourier Transform (properly called a DFT, commonly called an FFT). The analog Fourier Transform produces a continuous waveform where all possible frequencies are represented with zero side lobe interference. In the discrete world of the computer, the DFT is inherently less accurate than its analog counterpart. The DFT only allows a finite number of frequencies to be calculated for, which introduces some error. The purpose of the windowing functions is to approximate the result of an analog Fourier Transform using discrete data, and the selection of a window type depends on a wide variety of factors. This discussion is intended to give you an understanding of the practical results of using a DFT to help you select the best window type and width for your data.

When performing a calculation in the frequency domain, the choice of window type affects the magnitude and accuracy of the result. To maximize the accuracy, a scaling window is applied to the original signal to obtain a new, but related time function.

In addition to the input signal, the window width also has an effect on the selection of the window type. The window width affects the number of spectral lines (the frequency resolution of the calculation, which is equal to the sample rate of the input channel divided by the window width) as well as the start and end points of the data in the window (they should be equal for the best results). More information about the window width is provided in a later section.

Waveforms can be classified as either continuous or transient, and continuous waveforms can be further broken down as either periodic or non-periodic. Periodic waveforms have an integral number of complete cycles and the start and end points are equal. A waveform is non-periodic if it does not contain an integral number of cycles or does not have the same start and end points. A transient waveform consists of a single event followed by (in some cases also preceded by) a steady state value.

The DFT algorithm assumes that the waveform being analyzed is periodic and is infinitely long. One of the fall outs of this assumption is that the value of the first point in the window is equal to the value of the last point in the window. However, in most cases the waveform is non-periodic and even transient, so the start and end points do not match.

To "trick" the DFT algorithm into believing that this window of data is periodic, we can match the end points using a window type other than Rectangular (which actually performs no scaling at all). Many window scaling functions multiply the start and end points by zero to make the waveform appear periodic. This is especially useful for waveforms which consist of a large number of frequencies, in which case it is difficult to acquire an integer number of cycles. (To see the effect of a specific window type on the end points, perform a Forward FFT with the window, then perform an Inverse FFT on the result and compare it to your original waveform.)

Selecting A Window Type

Finally, we are to the point where we can select a window type. When making the selection, you must answer these questions:

- “Is the source signal periodic, non-periodic, or transient?”

  For non-periodic and transient signals, selecting a window type which zeros out the first and last points may provide more accurate results. If the signal is periodic, this question is not as important as the others.

- “Do the frequencies of interest fall on a spectral line, or are they in between spectral lines?”

  If the frequencies fall directly on the spectral lines (the frequencies being calculated by the FFT), then the “Best Case” values for each window can be used to decide which window to use. When the frequencies fall between spectral lines or you are not sure where they will fall, the “Worst Case” values provide a better response.

- "Are my frequencies of interest close together or spread out?"

  If the frequencies of interest are concentrated, select a window with a smaller main lobe width and greater side lobe attenuation to reduce interference. If the frequencies of interest are spread out, the effect of the main lobe is less pronounced than the effect of the spectral lines.

Window Width Response

Figure 14-4 lists the different windows available in Snap-Master, along with information concerning their response. Use this figure as a guideline in comparing the different window types for use in your particular application. Each window type is described in more detail in the following sections, and includes pictures of the frequency response for each window.

The Main Lobe Width is expressed in terms of Spectral Lines, where the resolution of the frequency domain result is a function of the sample rate of the source data and the window width. In general, the larger the number of spectral lines in the main lobe (at the frequency being measured), the larger the bandwidth of the window. If “skirted” is listed in the table (which means there are no appreciable side lobes), then the window has a “wide” bandwidth.

The Side Lobe Height lists the peak amount of attenuation at the first side lobe from the main lobe. Attenuation of the side lobes affects the amount of energy shown at frequencies adjacent to high strength signals, which becomes important for signals with signal components that are close together. For windows that are skirted, the lowest amplitude response is listed.

If any window type other than the Rectangular window is used, some of the energy from the time domain is eliminated. As a result, the apparent magnitude in the FFT would appear to be less than the magnitude in the time domain. Therefore, if a 1.0 volt sine wave is the input, the results should be corrected so that the amplitude at the frequency of the sine wave is 1.0 volt. The Amplitude Correction factor is automatically applied by Snap-Master to the FFT data.

In addition, the standard FFT algorithm produces a result where half of the energy is in the positive frequency range and half in the negative frequency range. Because most users expect that 1 volt in the time domain should correspond to 1 volt in the frequency domain, the FFT element automatically adjusts the output so the results are more easily understandable to the general user.

The maximum amplitude resolution of the FFT depends on the source of your data. For data acquired with the Data Acquisition Module, the resolution is determined by the number of bits used in the Analog-to-Digital conversion. If you are using the Wave Generator element or the General Analysis Time function, then the resolution is fixed by the 24 bit floating point number. The FFT element calculates its values based on a 24 bit floating point number. As a result, the computer's processing accuracy for the FFT will only minimally affect the dynamic range.

The following table lists the resolution and corresponding dynamic range in decibels (which is equal to 20*log(number of values)).

Bits	Number of Values (2^{Bits})	Dynamic Range (20 log # Values)	Resolution (1/# Values)
8	256	48.2 dB	0.391%
12	4,096	72.2 dB	0.024%
14	16,384	84.2 dB	0.006%
16	65,536	96.3 dB	0.0015%
24	16,777,216	144.5 dB	0.0000060%

Note: All data and plots for the FFT windows were obtained directly from Snap-Master, so some results may vary from the theoretical responses. The results were obtained by generating the data with the Analysis element, performing a Forward FFT with the FFT element, and measuring the response using the Display element with a dB(20x) scale on a Mag vs. F plot.

Window Type	Main Lobe Width (Spectral Lines)	Side Lobe Height (dB)	Amplitude Correction Factor
Blackman	47	< -100	2.38
Blackman-Harris	10	-92.9	2.79
Bohman	48	-47.0	2.47
Cauchy	19	-36.0	3.02
Cosine 4th Power	29	< -100	2.67
Cosine Tapered	13	-31.2	1.18
Exact Blackman	7	-68.2	2.34
Exponential	skirted	-73.3	1.58
Ext. Cosine Bell	19	-34.5	1.11
Flat-Top	skirted	-84.7	1.00
Gaussian	115	-28.4	1.51
Half Cycle Sine	115	-82.7	1.57
Hamming	5	-42.7	1.85
Hann	56	-96.4	1.00
Hanning-Poisson	131	-35.6	2.31
Kaiser-Bessel	16	-85.6	2.48
Parabolic	116	-80.6	1.50
Parzen	8	-53.6	2.67
Poisson	40	-30.5	3.16
Rectangular	skirted	-13.5	1.00
Riemann	116	-85	1.70
Sine 3rd Power	40	< -100	2.36
Triangular	124	-26.9	4.00

Figure 14-4 FFT Window Types

Window Effects Illustrated

To illustrate the effects of selecting a window type, three examples are presented with the Forward FFT calculated using three different windows: Rectangular, Triangular, and Blackman-Harris. The spectral lines are set to be at every 1 Hz (the sample rate is 1000 and the window width is 1000).

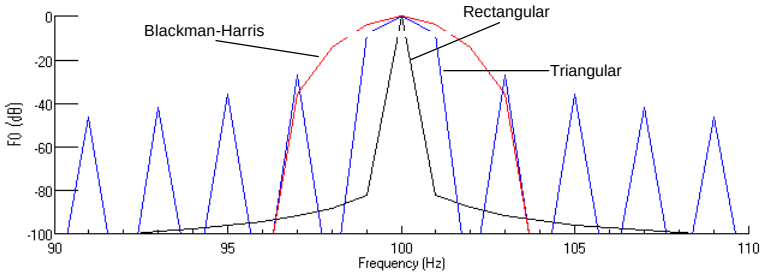


Figure 14-5 Response of FFT Windows on a Single Frequency

Figure 14-5 shows the effects of the different window types on an input signal with a single 100 Hz sine wave. Each window type shows a strong frequency component at 100 Hz, but on either side of the main frequency the windows differ. Remember that the ideal response would be a single straight line at 100Hz and zero elsewhere.

The Rectangular window produces the closest result to the ideal, due largely to the fact that the main signal falls on a spectral line. In this “best” case scenario, the Rectangular window has a single spectral line at the frequency of interest, with an amplitude of -82 dB at 99 and 101 Hz (the adjacent spectral lines).

The Blackman-Harris window produces a similar result, but the width of the main lobe is greater than the Rectangular window. As a result, it appears that energy is “measured” at 3 Hz on either side of the main frequency. The Main Lobe Width for the best case is 7 spectral lines for the Blackman-Harris window regardless of the frequency resolution, so ±3 Hz is the net result with our resolution. Because the remainder of the spectrum is below -100 dB, the overall response is adequate.

Finally, the Triangular window shows the same frequency component at 100 Hz (with spill over energy at ±1 Hz) , but it also shows energy at ±3 Hz, ±5 Hz, etc. In the best case the Triangular window has a small main lobe width of 3 spectral lines, but the Side Lobe Height is only 27 dB down from the peak, which is much less than the other window types. For the case where there is a strong frequency component on a spectral line, the Triangular window does not provide the most accurate results.

Now let’s look at a case where the frequencies are far apart, but one of the frequencies does not fall on a spectral line. We will still look at our 100 Hz signal, but we will add a 200.5 Hz signal as well. The 200.5 Hz signal falls directly between the spectral lines at 200 Hz and 201 Hz so we will not see a perfect representation of the signal, but we should know that something is happening in that frequency range.

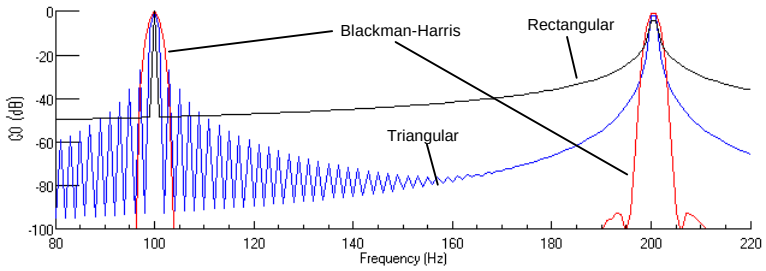


Figure 14-6 Response of FFT Windows on Spread Out Frequencies

Around 100 Hz, we see the same type of response for the Blackman-Harris and Triangular windows as when there was a single frequency. However, the Rectangular window does not have as much attenuation as before (only about -50 dB compared to the -100 dB for the single frequency signal). At around 200.5 Hz the width of the main lobe is much wider, which affects all other frequencies in the spectrum. As a result, when the frequency being measured does not fall directly on a spectral line, the Rectangular window loses its accuracy.

With the 200.5 Hz signal falling between spectral lines, the benefit of the Blackman-Harris window becomes evident. Even in this “worst” case scenario, the width of the main lobe is only 10 spectral lines and the closest side lobe is 92.9 dB down from the amplitude of the main frequency. The larger width of the main lobe that seemed large for a single frequency becomes an excellent trade-off when the frequency being measured does not coincide with the spectral resolution of the result.

For the Triangular window, we still see the large number of side lobes around 100 Hz, but they diminish until almost gone around the 200.5 Hz signal. This tells us that the Triangular window is actually better with frequencies that do not fall on spectral lines. The width of the main lobe for the 200.5 Hz frequency is larger than the Blackman-Harris (especially at -60 dB), but the response is better for the Triangular than for the Rectangular window.

Now we need to look at the case where the frequencies of interest are both on spectral lines but are relatively close together. In Figure 14-7, a signal with a 100 Hz and a 103 Hz frequency component of equal magnitudes are measured.

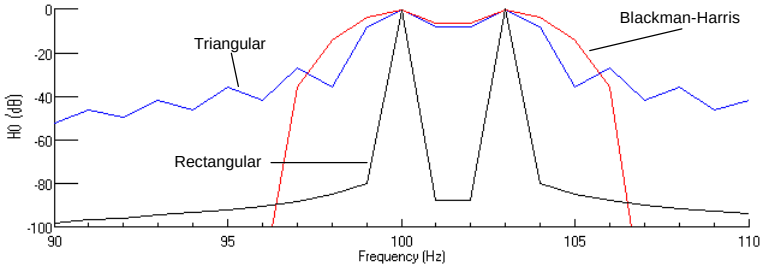
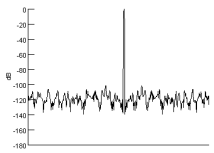
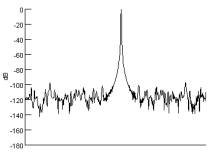


Figure 14-7 Response of FFT Windows on Concentrated Frequencies

Once again, because the frequencies fall directly on the spectral lines, the Rectangular window provides the closest response to the ideal. Neither the Blackman-Harris nor the Triangular window displays a sufficient signal drop in between the frequencies being measured. For the Blackman-Harris window, this is because the main lobe width is always 7 spectral lines and there are not enough spectral lines between the frequencies for a sufficient drop. The Triangular window suffers from its large side lobe height which interferes on either side of the main frequencies to produce inaccurate readings at the off frequencies.

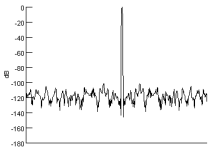
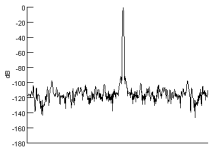
There are other combinations of frequency cases, but these three provide a good illustration of the interdependence between the window type, the width of the main lobe, and the number of spectral lines. The following sections discuss each window type and its response in both the "best" (where a single frequency falls on a spectral line) and "worst" (where a single frequency is between spectral lines) cases.

Blackman

	Best Case	**Worst Case**
Frequency Response		
60 dB Bandwidth (Spectral Lines)	5 (-20.4 dB)	10
Main Lobe Width (Spectral Lines)	5	47
Side Lobe Height	-129.1 dB	-100.0 dB

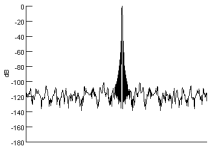
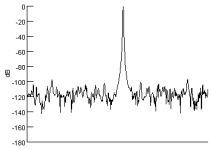
The Blackman window works well in both the best and worst cases. In the best case, the main lobe is narrow, with an extreme drop off after the main lobe. In the worst case the main lobe width is wider, but most of the energy is below -60 dB.

Blackman-Harris

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	7 (-35.7 dB)	8 (-54.8 dB)
Main Lobe Width (Spectral Lines)	7	10
Side Lobe Height	-122.3 dB	-92.9 dB

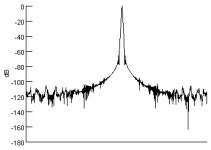
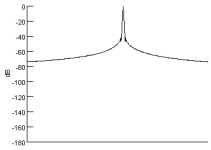
The Blackman-Harris window (profiled in more detail in the examples from the previous section) is an excellent window in both the best and worst cases. The main lobe width is narrow with a good drop off and low side lobes.

Bohman

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	5 (-19.1 dB)	10 (-57.4 dB)
Main Lobe Width (Spectral Lines)	5	48
Side Lobe Height	-47.0 dB	-115.0 dB

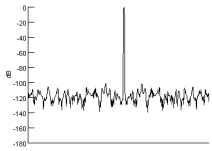
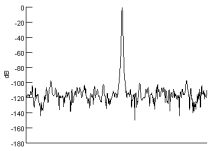
The Bohman window is more useful when the frequencies do not fall directly on the spectral lines. In the best case the main lobe is narrow and there is a drop from -20 dB to below -60 dB, but the side lobe is only attenuated 47 dB. The worst case has a wide main lobe width, but the majority of the lobe is below -60 dB.

Cauchy

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	19 (-56.9 dB)	113
Main Lobe Width (Spectral Lines)	19	10
Side Lobe Height	-66.2 dB	-36.0 dB

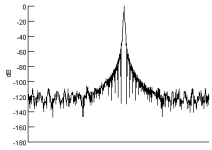
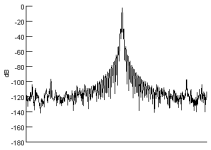
The Cauchy window has respectable performance in the best case, assuming the width of the main lobe does not interfere with measurements for frequencies that are within nine spectral lines. For the worst case, the side lobe height is higher than with other windows, but the overall response is approximately skirted around -75 dB.

Cosine 4th Power

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	5 (-15.6 dB)	10
Main Lobe Width (Spectral Lines)	8	29
Side Lobe Height	-123.0 dB	-115.6 dB

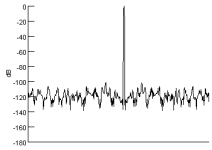
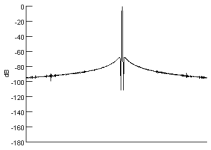
In both the best and worst cases, the Cosine 4th Power window provides an accurate representation of the source data. The main lobe width and drop off in the best case are very good, and much of the main lobe energy in the worst case is below -60 dB.

Cosine Tapered

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	19 (-51.4 dB)	18 (-49.4 dB)
Main Lobe Width (Spectral Lines)	13	6
Side Lobe Height	-46.6 dB	-31.2 dB

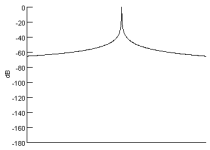
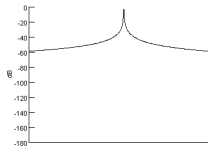
A ringing around the main lobe is a characteristic of cosine-based windows. The main lobe width for both cases is fairly narrow, but the side lobes are well above -60 dB. This makes the Cosine Tapered window sufficient for cases when the frequencies of interest are well known.

Exact Blackman

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	5 (-20.9 dB)	6 (-36.7 dB)
Main Lobe Width (Spectral Lines)	7	7
Side Lobe Height	-123.7 dB	-68.2 dB

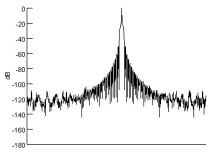
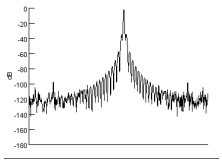
The Exact Blackman window behaves like other windows sharing its namesake, with a narrow main lobe width and a severe drop off below -60 dB. The side lobe height in the worst case is not as low as the Blackman-Harris window, but this is another good window choice when the frequencies being measured fall on or between the spectral lines.

Exponential

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	319	695
Main Lobe Width (Spectral Lines)	skirted	skirted
Side Lobe Height	-80.0 dB	-73.3 dB

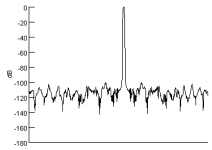
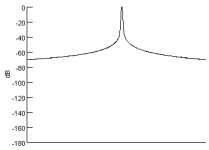
The Exponential window has a skirted response for both the best and worst cases. This window is a classic “wide bandwidth” window, as evidenced by the large number of spectral lines in the 60 dB Bandwidth. This window zeroes out the latter part of the time domain data (which would otherwise be composed of noise), and is often used for stimulus-response testing of mechanical structures.

Extended Cosine Bell

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	19 (-45.8 dB)	26 (-51.4 dB)
Main Lobe Width (Spectral Lines)	19	10
Side Lobe Height	-50.6 dB	-34.5 dB

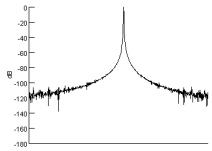
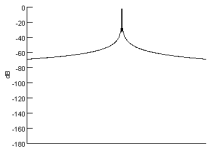
Another cosine based window type with ringing around the main lobe. Like the Cosine Tapered window, the Extended Cosine Bell window has high side lobes with a relatively narrow main lobe width.

Flat Top

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	9 (-15.9 dB)	187
Main Lobe Width (Spectral Lines)	26	skirted
Side Lobe Height	-109.2 dB	-84.7 dB

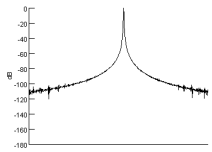
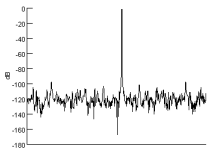
In the best case the Flat Top window (often used for calibration purposes) has a wider main lobe, but most of the energy is below -60 dB. In the worst case, the response is skirted. As a result where the frequencies of interest fall in respect to the spectral lines determines if this window is classified as a wide or narrow band window.

Gaussian

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	21	415
Main Lobe Width (Spectral Lines)	115	2
Side Lobe Height	-88.8 dB	-28.4 dB

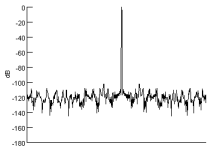
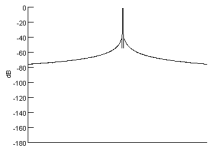
The Gaussian window behaves better in the best case, but not much. In the best case the main lobe width is wide, with most of the energy is below -60 dB. In the worst case, the main lobe width is very narrow, but the side lobe is not attenuated very much and the result is virtually skirted.

Half Cycle Sine

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	31	2 (-2.1 dB)
Main Lobe Width (Spectral Lines)	115	13
Side Lobe Height	-82.7 dB	-111.3 dB

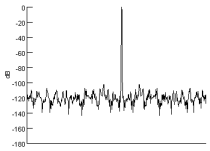
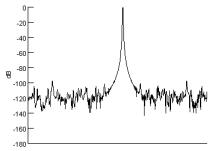
The Half Cycle Sine window responds impressively in the worst case, with a severe drop off in the main lobe below 60 dB. The best case shows most of the main lobe energy below -60 dB, with a virtually skirted response.

Hamming

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	3 (-7.4 dB)	95
Main Lobe Width (Spectral Lines)	5	4
Side Lobe Height	-109.7 dB	-42.7 dB

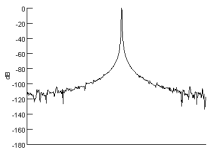
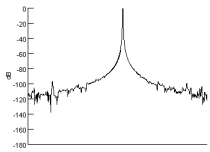
The Hamming window is another case where there is a large difference in response depending on where the frequencies of interest lie. The best case scenario has excellent response with a narrow main lobe and good attenuation below -60 dB. In the worst case the response is almost skirted with a relatively high side lobe. Note that the side lobe rises about 20 dB from the bottom of the main lobe before the skirting begins.

Hann

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	3 (-6.0 dB)	14 (-58.5 dB)
Main Lobe Width (Spectral Lines)	9	56
Side Lobe Height	-117.7 dB	-96.4 dB

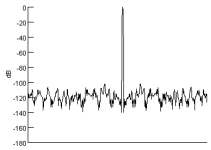
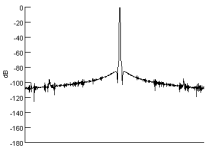
The Hann window exhibits excellent best case response with a narrow main lobe and 60 dB bandwidth. The worst case has a wider main lobe, though most of the energy is below 60 dB. Side lobe height in both cases is negligible.

Hanning-Poisson

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	21	19
Main Lobe Width (Spectral Lines)	131	4
Side Lobe Height	-93.9 dB	-35.6 dB

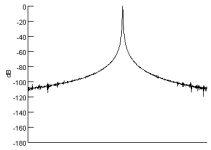
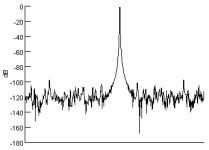
The Hanning-Poisson window has a consistent 60 dB bandwidth between the best and worst cases, but the side lobe height in the worst case is much higher than the best case. In addition the width of the main lobe is wider in the best case, even though much of the energy is below -60 dB.

Kaiser-Bessel

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	7 (-56.4 dB)	6 (-31.4)
Main Lobe Width (Spectral Lines)	7	16
Side Lobe Height	-121.9 dB	-85.6 dB

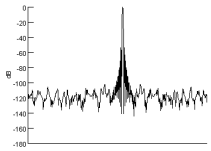
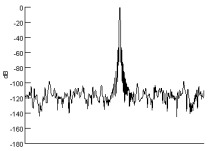
Like the Hanning-Poisson window, the Kaiser-Bessel window has a similar 60 dB bandwidth between cases. The main lobe is wider in the worst case, but the difference between the best and worst case is not as great as with other cases.

Parabolic

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	35	9
Main Lobe Width (Spectral Lines)	116	44
Side Lobe Height	-80.6 dB	-101.8 dB

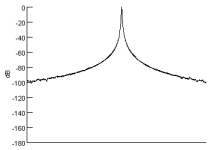
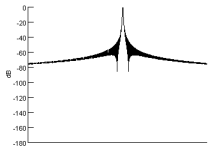
The Parabolic window operates better in the worst case with a relatively narrow 60 dB bandwidth. The best case response is virtually skirted with much of the main lobe energy below 60 dB.

Parzen

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	7 (-41.8 dB)	6 (-26.2 dB)
Main Lobe Width (Spectral Lines)	7	8
Side Lobe Height	-53.9 dB	-53.6 dB

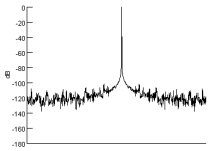
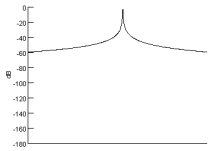
The Parzen window has a narrow main lobe in both cases, but the side lobe height is not negligible. One benefit of the Parzen window is the consistent response between the best and worst cases.

Poisson

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	62	30
Main Lobe Width (Spectral Lines)	40	10
Side Lobe Height	-52.8 dB	-30.5 dB

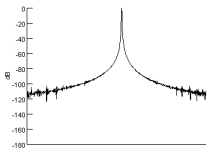
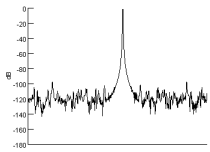
The Poisson window has a wide bandwidth, as indicated by the large number of spectral lines in the 60 dB bandwidth. In addition, the side lobe attenuation is smaller than with other window types. As a result this window is best used on signals with a single frequency component or when the frequencies are relatively far apart.

Rectangular

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	1 (0 dB)	642
Main Lobe Width (Spectral Lines)	42	skirted
Side Lobe Height	-104.0 dB	-13.5 dB

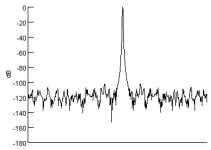
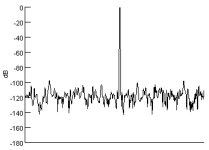
The Rectangular window is actually equivalent to no windowing at all, since all points within the window width are multiplied by 1. The response in the best case is excellent, as documented in the examples at the beginning of this section. The worst case response is not as good with an absolute attenuation of about -74 dB.

Riemann

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	26	10
Main Lobe Width (Spectral Lines)	116	46
Side Lobe Height	-85.0 dB	-101.7 dB

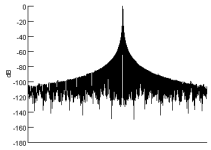
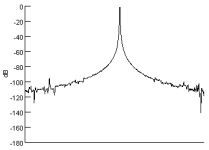
With much of the main lobe energy below -60 dB, the Riemann window exhibits consistent “wide bandwidth” response to both cases. The side lobes are negligible, making this window more appropriate when the frequencies of interest do not fall directly on the spectral lines.

Sine 3rd Power

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	10	4 (-10.6 dB)
Main Lobe Width (Spectral Lines)	40	9
Side Lobe Height	-108.1 dB	-111.4 dB

Like the Half Cycle Sine window, the Sine 3rd Power window has excellent response in the worst case with an impressive drop off below -60 dB. In the best case, the wide bandwidth response is adequate because the height of the side lobe is negligible.

Triangular

	Best Case	Worst Case
Frequency Response		
60 dB Bandwidth (Spectral Lines)	3 (-7.8)	28
Main Lobe Width (Spectral Lines)	3	124
Side Lobe Height	-26.9 dB	-85.3 dB

As seen in the examples at the beginning of this section, the Triangular window has very different responses depending on the location of the frequencies with respect to the spectral lines. This window is better suited towards the worst case where the frequencies of interest and the spectral lines do not coincide.

14.4. Window Width

The other window parameter we can adjust is the window width. The window width affects the resolution of the frequency calculation (the spectral lines) and also affects accuracy of the windowing function by enclosing a complete period of the source waveform.

The FFT element produces a result frame after the specified number of data points are input from the data channel. For example, if you have one time domain frame with 10,000 points of data and are performing an FFT function on 4096 points, you will output either two or three frames of data (depending on the Partial Frames setting). If Partial Frames is set to Zero Extend, the FFT element produces one frame for the first 4096 point, one for the second 4096 points, and one for the remaining 1808 points. If Partial Frames is set to Drop, only the first two result frames are produced.

The time delay for the first FFT result frame is equal to the sample rate of the input channel multiplied by the window width (with a small amount of additional time required to process the data). In this sense, the FFT element does not produce real-time results (which would update the frequency domain calculation as each new data point is acquired), but the results are presented after all points in the window are processed so they appear during acquisition.

Available Widths

The FFT element allows window widths between 2 and 16,384 points. The width must be an even multiple of 2, 3, 5 and/or 7. This means that it is as simple to specify a 1000 point FFT as a 1024 point FFT. Odd valued window widths are not allowed, so the width must always be divisible by 2.

Window widths that are not an integral power of 2 take longer to process than widths that are multiples of 2 only. The effect is more pronounced at higher window widths, which is why a 16,000 point FFT takes longer to calculate than a 16,384 point FFT.

Frequency Resolution and Spectral Lines

As illustrated when describing the “best” and “worst” case scenarios for the various window widths, the number and location of the spectral lines has a tremendous impact on the accuracy of the frequency domain calculation. This conversion of the continuous frequency spectrum into equally spaced spectral lines is the frequency domain counterpart of time domain sampling, where time is separated into discrete slices which are processed by the computer.

The resolution of the frequency domain (or the spectral line interval) is calculated as follows:

$$SpectralLines = \frac{SampleRate}{WindowWidth}$$

The highest spectral line computed by the FFT element is set to one-half the sampling frequency of the time domain data to prevent aliasing of the data. This is also because the FFT algorithm produces an equal number of real and imaginary values (using complex math).

Forcing Periodicity

Selecting a window width to create the most spectral lines is not always the best solution to providing the most accurate results. While some window types force the data to zero on the ends to simulate periodicity (which inherently loses some of the original data), some do not and the choice of window length has an impact on the results.

Remember from the discussion about the FFT in the Window Types section that the FFT algorithm assumes that the incoming signal is periodic, even if it is not. When selecting a width, it is important to match the first and last points in the window as closely as possible to increase the accuracy at the end points of the window. If the first and last points are not equal, then smearing (similar to the effect shown in Figure 14-7) in the frequency domain will occur.

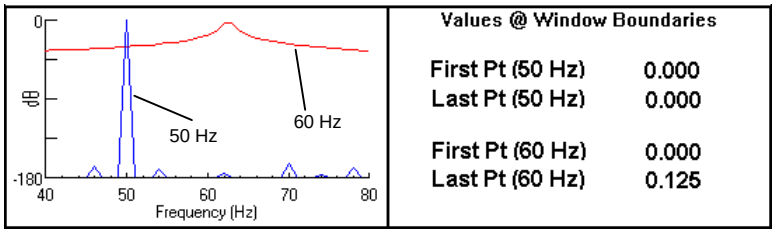


Figure 14-8 Effect Of Window Width On FFT Result

To illustrate the importance of the window width, Figure 14-8 shows the results of a Forward FFT of a 50 Hz and a 60 Hz sine wave using the Rectangular window type. The sample rate of the source data was 1000 Hz and the window width was 1000 points, producing a spectral line at every 1 Hz. This corresponds to the “best” case for the Rectangular window, which should produce good results for each waveform.

For the 50 Hz waveform, we see the results we expected. There is a sharp peak at 50 Hz with little side lobe intervention. However, the 60 Hz signal looks more like the “worst” case. If we drag a cursor over the 60 Hz response, we see the peak appears at 62 and 63 Hz!

Looking at the data on the right side of Figure 14.4-8 shows us why the discrepancy exists. For the 50 Hz waveform, the start and end points are equal. This maintains the periodicity assumption of the FFT algorithm. For the 60 Hz waveform the start and end points are not equal, so there is some frequency smearing present. As a result, our so-called “worst” case also applies to instances where the window does not force the start and end points to zero.

14.5. Tutorial: Performing a Forward FFT

In addition to these tutorial sections, there are a number of sample equation files included with the Frequency Analysis module that you may use for reference.

These tutorials use the A/D Demo element, the FFT element, and the Display element. The instrument we will use for these tutorials is shown in Figure 14-9.

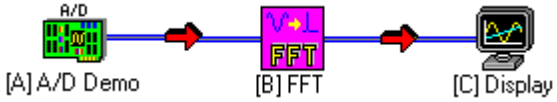


Figure 14-9 Instrument for Frequency Analysis Tutorials

Building the Instrument

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place the A/D Demo, FFT, and Display elements in the instrument.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the A/D Demo element to the FFT element, and the FFT element to the Display element.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as FAEX1.

Configuring the A/D Demo Element

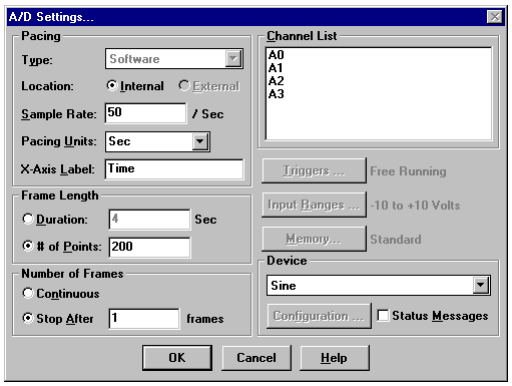


Figure 14-10 A/D Demo Settings

1. Open the A/D Demo element by double clicking on the icon in the instrument window.

2. Change the Sample Rate to 50.

3. Change the Number of Frames to Stop After 1 frame.

4. Press the OK button to close the A/D Demo Settings.

5. Save the instrument with the button or with the File menu, Save command.

Calculating The Forward FFT

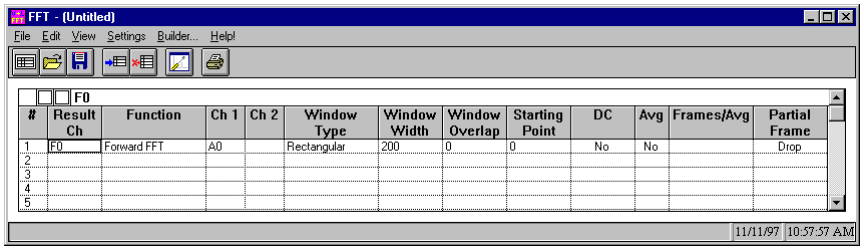

FFT - (Untitled)
File Edit View Settings Builder... Help!
F0
Result Ch Function Ch 1 Ch 2 Window Type Window Width Window Overlap Starting Point DC Avg Frames/Avg Partial Frame
1 F0 Forward FFT A0 Rectangular 200 0 0 No No Drop
2
3
4
5
11/11/97 10:57:57 AM

Figure 14-11 FFT Settings for Forward FFT Tutorial

1. Open the FFT element by double clicking on the icon in the instrument window.

2. Open the Equation Builder by pressing the button, or select the Builder menu command.

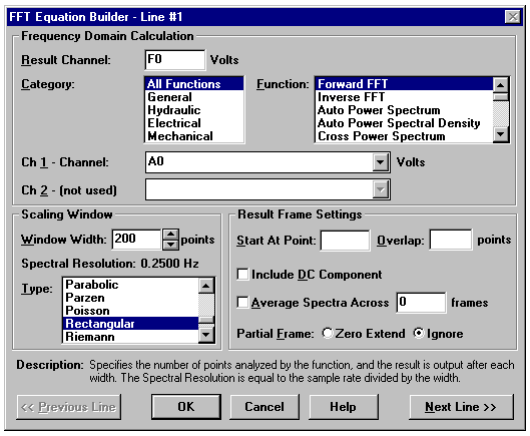

FFT Equation Builder - Line #1
Frequency Domain Calculation
Result Channel: F0 Volts
Category: All Functions General Hydraulic Electrical Mechanical
Function: Forward FFT Inverse FFT Auto Power Spectrum Auto Power Spectral Density Cross Power Spectrum
Ch 1 - Channel: A0 Volts
Ch 2 - (not used)
Scaling Window
Window Width: 200 points
Spectral Resolution: 0.2500 Hz
Type: Parabolic Parzen Poisson Rectangular Riemann
Result Frame Settings
Start At Point: Overlap: points
Include DC Component
Average Spectra Across 0 frames
Partial Frame: Zero Extend Ignore
Description: Specifies the number of points analyzed by the function, and the result is output after each width. The Spectral Resolution is equal to the sample rate divided by the width.
<< Previous Line
OK
Cancel
Help
Next Line >>

Figure 14-12 FFT Equation Builder Settings for Forward FFT

3. In the Result Channel text box, type *F0*.

4. Select channel A0 from the Ch 1 list.

5. In the Window Width text box, type *200*.

   If you enter an invalid Window Width, a message box appears asking you to select a valid width. The closest values to the one you entered are listed.

   According to our rules for window width, we must try to match the start and end points of the data within the window width. Channel 0 of the A/D Demo contains a 0.5 Hz cosine wave. At 100 Hz the waveform will repeat every 2 seconds, so four seconds contains two periods. Therefore, because the start and end points are the same and we are capturing 2 complete periods of the waveform, our results will be good. (Our frequency resolution is also good, which is equal to 50 Hz / 200 points = a spectral line every 0.25 Hz).

6. Press the OK button to close the FFT Equation Builder.

   When you return to the FFT equation table, the settings from the Equation Builder are entered in the first row of the table, which is where the selection box is.

7. Close the FFT equation table using the File menu, Close Equations command.

8. Save the instrument with the button or with the File menu, Save command.

Running The Instrument

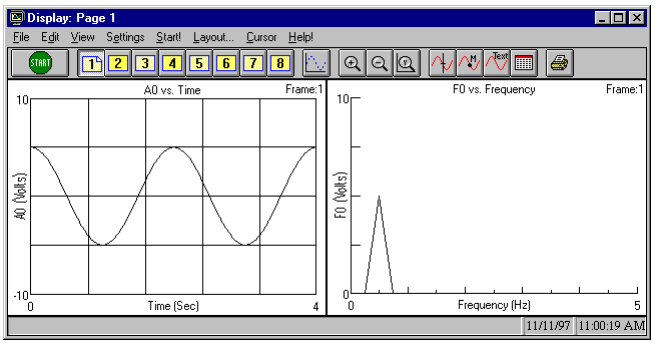


Figure 14-13 Results of Forward FFT Tutorial

When you Start the instrument, the plot of A0 appears in real time, but the frequency plot waits until the entire window length is acquired before displaying the information. (If the plots do not appear, you have Auto Layout turned off. Configure a y vs. t plot for A0 and a mag vs. f plot for F0.) Figure 14-13 has been formatted to show the plot of F0 from 0 to 5Hz on the X-axis with tick marks instead of gridlines.

To verify the frequency of the input channel, place a cursor on the frequency plot using the button. At 0.5 Hz, an amplitude of 4.998727 volts is displayed, and at all other frequencies the magnitude is approximately 0.

If you are interested in investigating the effects of window width on the accuracy of the FFT, try changing the window width to 180 points or the A/D Demo sample rate to 51. This changes many of the window parameters such as the spectral lines, making the start and end points unequal, and analyzing less than two complete cycles of the source waveform. Less accurate results should be displayed in the plot of F0.

14.6. Tutorial: Performing an Inverse FFT

Now that we have a signal in the frequency domain, we can convert it back to the time domain and compare it with the original signal. The conversion from frequency to time is accomplished using the Inverse FFT function. (If you changed the A/D Demo sample rate or the FFT window width, be sure to change the values back to 50 Hz and 200 points before continuing.)

Calculating An Inverse FFT

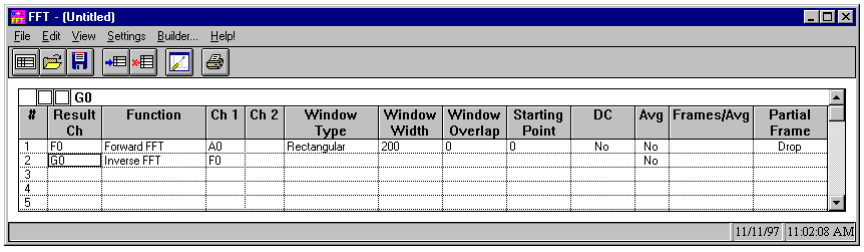

FFT - (Untitled)
File Edit View Settings Builder... Help!
G0
Result Ch Function Ch 1 Ch 2 Window Type Window Width Window Overlap Starting Point DC Avg Frames/Avg Partial Frame
1 F0 Forward FFT A0 Rectangular 200 0 0 No No Drop
2 G0 Inverse FFT F0 No
3
4
5
11/11/97 11:02:08 AM

Figure 14-14 FFT Settings for Inverse FFT Tutorial

1. Open the FFT element by double clicking on the icon in the instrument window.

2. Position the selection box in the second row.

3. Open the Equation Builder by pressing the button, or select the Builder menu command.

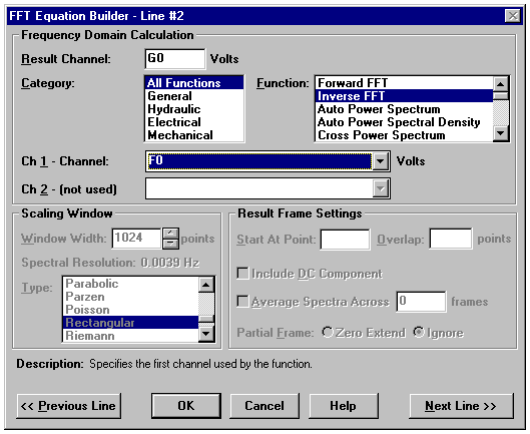


Figure 14-15 FFT Equation Builder Settings for Inverse FFT

4. In the Result Channel text box, type *G0*.

5. Select Inverse FFT from the Function list.

   Notice that when you select the Inverse FFT function, the Input Signal list shows only the frequency domain channel. Also notice that the items in the Window and Result Frame Settings are disabled. This is because these selections are invalid for the Inverse FFT function.

6. Select channel F0 from the Ch 1 list.

7. Press the OK button to close the FFT Equation Builder.

8. Close the FFT equation table using the File menu, Close Equations command.

9. Save the instrument with the button or with the File menu, Save command.

Running the Instrument

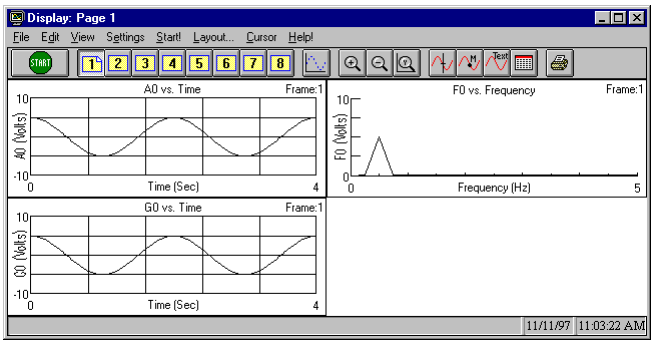


Figure 14-16 Results of Inverse FFT

When you start the instrument, the data for channel A0 appears on screen in real time. When the end of the 200 point window width is reached, the FFT is calculated and output in the F0 vs. Frequency plot in the upper right of the Display window. After the FFT is calculated, then the Inverse FFT can be calculated, which is output in the plot of G0. The reconstruction of the waveform in channel G0 is identical to the original channel A0.

14.7. Tutorial: Cross Power Spectrum

The next tutorials use functions that operate on two channels. For this, we can either use a different channel from the same source or we can add a second input source. The next section will add a second A/D Demo to the instrument, which we will configure to output a sawtooth waveform.

Adding The Second A/D Demo

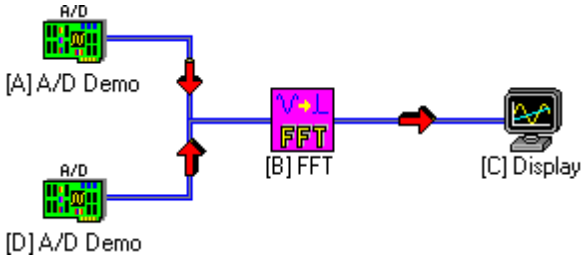


Figure 14-17 Instrument with Two A/D Demos

1. Place the second A/D Demo element in the instrument.

2. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

3. Connect the second A/D Demo element to the FFT element.

4. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

5. Open the second A/D Demo element by double clicking on the icon in the instrument window.

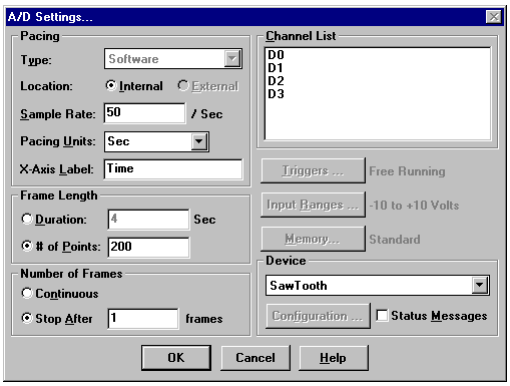


Figure 14-18 A/D Settings for Second A/D Demo

6. Change the Sample Rate to 50.

7. Change the Number of Frames to Stop After 1 frame.

8. From the Device list, selecting SawTooth.

   The SawTooth function calculates its period from the Sample Rate and Number of Points, and these settings only use a fraction of the cycle. As a result, the output for this example is an increasing ramp function.

9. Press the OK button.

10. Save the instrument with the button or select the File menu, Save Instrument command.

Calculating the Cross Power Spectrum

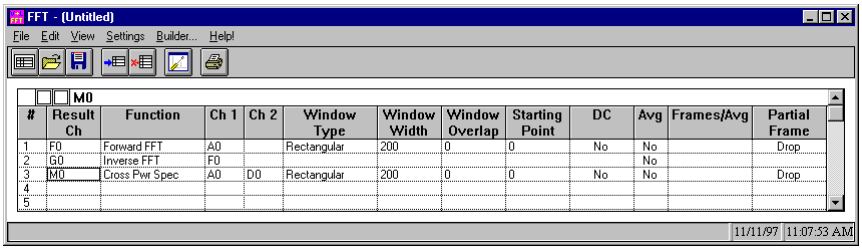

FFT - (Untitled)
File Edit View Settings Builder... Help!
M0
Result Ch Function Ch 1 Ch 2 Window Type Window Width Window Overlap Starting Point DC Avg Frames/Avg Partial Frame
1 F0 Forward FFT A0 Rectangular 200 0 0 No No Drop
2 G0 Inverse FFT F0 No
3 M0 Cross Pwr Spec A0 D0 Rectangular 200 0 0 No No Drop
4
5
11/11/97 11:07:53 AM

Figure 14-19 FFT Settings for Cross Power Spectrum

1. Open the FFT element by double clicking on the icon in the instrument window.

2. Position the selection box in the third row.

3. Open the Equation Builder by pressing the button, or select the Builder menu command.

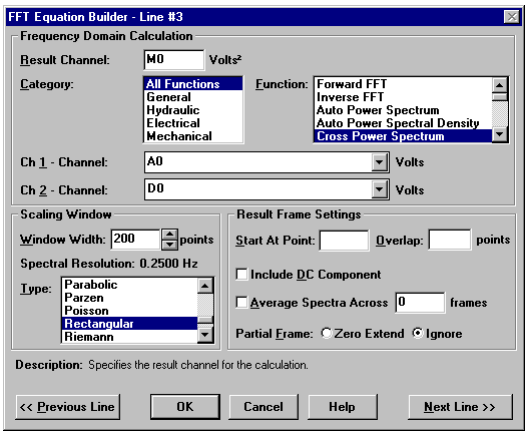

FFT Equation Builder - Line #3
Frequency Domain Calculation
Result Channel: M0 Volts²
Category: All Functions General Hydraulic Electrical Mechanical
Function: Forward FFT Inverse FFT Auto Power Spectrum Auto Power Spectral Density Cross Power Spectrum
Ch 1 - Channel: A0 Volts
Ch 2 - Channel: D0 Volts
Scaling Window
Window Width: 200 points
Spectral Resolution: 0.2500 Hz
Type: Parabolic Parzen Poisson Rectangular Riemann
Result Frame Settings
Start At Point: Overlap: points
Include DC Component
Average Spectra Across 0 frames
Partial Frame: Zero Extend Ignore
Description: Specifies the result channel for the calculation.
<< Previous Line OK Cancel Help Next Line >>

Figure 14-20 FFT Equation Builder Settings for Cross Power Spectrum

4. In the Result Channel text box, type *M0*.

5. Select Cross Power Spectrum from the Function list.

6. Select channel A0 from the Ch 1 list.

7. Select channel D0 from the Ch 2 list.

8. Set the Window Width to 200.

9. Press the OK button to close the FFT Equation Builder.

10. Close the FFT equation table using the File menu, Close Equations command.

11. Save the instrument with the button or with the File menu, Save command.

Running the Instrument

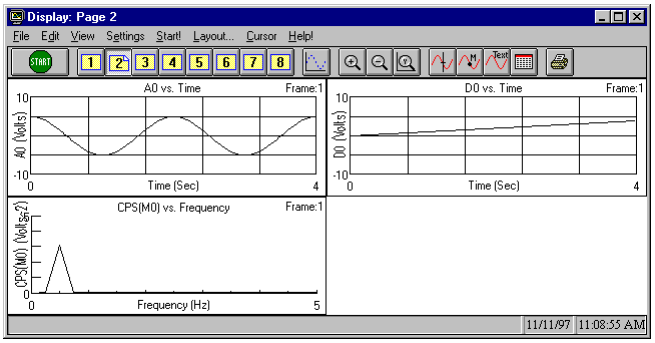


Figure 14-21 Results of Cross Power Spectrum

When you start the instrument, the data for channels A0 and D0 appear on screen in real time. When the end of the 200 point window width is reached, the cross power spectrum is displayed in the appropriate plot as M0. (Figure 14-21 shows a Y-T plot for channel A0, a Y-T plot for channel D0, and a Mag vs. F plot for channel M0. In addition, the X-Axis for channel M0 is set to display from 0 to 5, and the Y-Axis is set to display from 0 to 5). The results indicate a power component at 0.5 Hz and zero power in the rest of the spectrum. How do we interpret this information?

The result of the Cross Power Spectrum function determines the average amount of power common to both signals. If perform a Forward FFT of channel D0, you would see frequency components from just past 0 Hz (the DC Component) all the way to 32 Hz (the maximum frequency computed by the FFT in this case). This means that the input (D0) has power at 0.5 Hz, where the output (A0) also has power. Because the output (A0) has no power elsewhere in the frequency spectrum, the remainder of the Cross Power Spectrum is zero.

14.8. Tutorial: Transfer and Coherence Functions

The Transfer and Coherence functions are often calculated together, using the Coherence function to indicate the validity of the Transfer function.

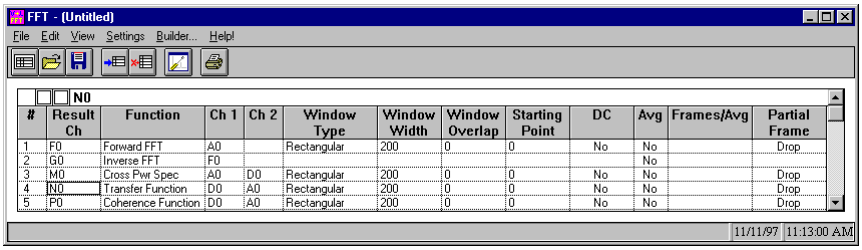

FFT - (Untitled)
File Edit View Settings Builder... Help!
N0
| Result Ch | Function | Ch 1 | Ch 2 | Window Type | Window Width | Window Overlap | Starting Point | DC | Avg | Frames/Avg | Partial Frame
1 | F0 | Forward FFT | A0 | | Rectangular | 200 | 0 | 0 | No | No | | Drop
2 | G0 | Inverse FFT | F0 | | | | | | | No | | |
3 | M0 | Cross Pwr Spec | A0 | D0 | Rectangular | 200 | 0 | 0 | No | No | | Drop
4 | N0 | Transfer Function | D0 | A0 | Rectangular | 200 | 0 | 0 | No | No | | Drop
5 | P0 | Coherence Function | D0 | A0 | Rectangular | 200 | 0 | 0 | No | No | | Drop
11/11/97 11:13:00 AM

Figure 14-22 FFT Settings for Transfer Function and Coherence

Calculating The Transfer Function

1. Open the FFT element by double clicking on the icon in the instrument window.

2. Position the selection box in the fourth row.

3. Open the Equation Builder by pressing the button, or select the Builder menu command.

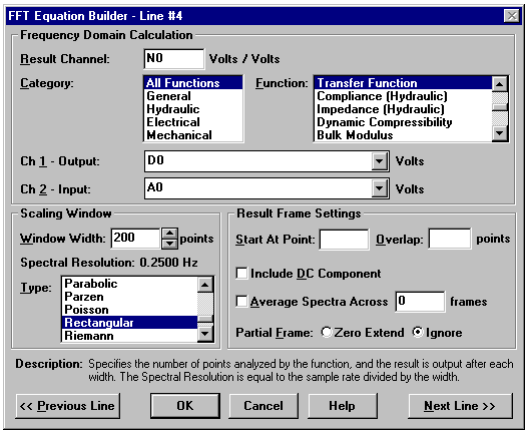

FFT Equation Builder - Line #4
Frequency Domain Calculation
Result Channel: N0 Volts / Volts
Category: All Functions, General, Hydraulic, Electrical, Mechanical
Function: Transfer Function, Compliance (Hydraulic), Impedance (Hydraulic), Dynamic Compressibility, Bulk Modulus
Ch 1 - Output: D0 Volts
Ch 2 - Input: A0 Volts
Scaling Window
Window Width: 200 points
Spectral Resolution: 0.2500 Hz
Type: Parabolic, Parzen, Poisson, Rectangular, Riemann
Result Frame Settings
Start At Point: Overlap: points
Include DC Component
Average Spectra Across 0 frames
Partial Frame: Zero Extend Ignore
Description: Specifies the number of points analyzed by the function, and the result is output after each width. The Spectral Resolution is equal to the sample rate divided by the width.
<< Previous Line
OK
Cancel
Help
Next Line >>

Figure 14-23 FFT Equation Builder Settings for Transfer Function

4. In the Result Channel text box, type *N0*.

5. Select Transfer Function from the Function list.

6. Select channel D0 from the Ch 1 list.

7. Select channel A0 from the Ch 2 list.

8. Set the Window Width to 200.

9. Press the Next Line button to create a new equation.

Calculating The Coherence Function

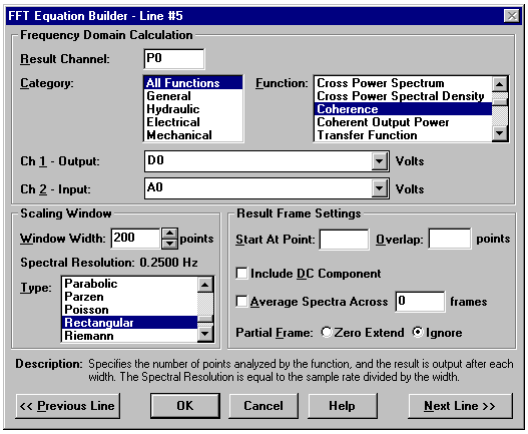


Figure 14-24 FFT Equation Builder Settings for Coherence Function

1. In the Result Channel text box, type *P0*.

2. Select Coherence Function from the Function list.

3. Select channel D0 from the Ch 1 list.

4. Select channel A0 from the Ch 2 list.

5. Set the Window Width to 200.

6. Press the OK button to close the FFT Equation Builder.

7. Close the FFT equation table using the File menu, Close Equations command.

8. Save the instrument with the button or with the File menu, Save command.

Running the Instrument

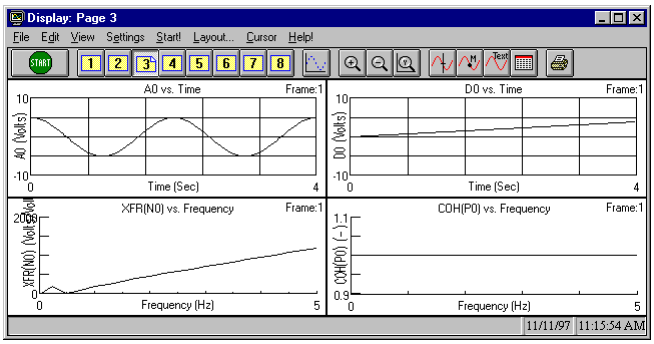


Figure 14-25 Results of Transfer Function and Coherence

When you start the instrument, the plots of channels A0 and D0 appear in real time. The remaining plots are displayed after the window length of 200 points is reached and the functions are calculated. Figure 14-25 shows a Y-T plot for channel A0, a Y-T plot for channel D0, a Mag vs. F plot for channel N0, and a Mag vs. F plot for channel P0. The plot of channel N0 has the X-Axis set to display from 0 to 5, and the Y-Axis to display from 0 to 2000. The plot of channel N0 has the Y-Axis set to display from 0.9 to 1.1.

In the lower right corner, the plot of the Transfer function shows a signal component at 0.5 Hz, which we expect to see from the sine wave in channel A0. From the Coherence function plot in the lower left, we see that the coherence ratio is one for the entire measured range of the frequency spectrum. This means that there are no other inputs to the system except D0, and A0 is the output.

Chapter 15. Utility Elements

15.1. Relay **15-1**
15.2. Tutorial: Relay **15-4**
15.3. Thermocouple Linearization **15-7**
15.4. Tutorial: Thermocouple Linearization **15-8**
15.5. Smoothing **15-12**
15.6. Tutorial: Smoothing **15-13**
15.7. Histogram **15-17**
15.8. Tutorial: Histogram **15-19**
15.9. MultiFrame **15-22**
15.10. Tutorial: MultiFrame **15-22**

The elements described in this chapter are designed for specialized functions (usually a special data analysis). While these elements may not have the wide range of applications as the main elements, they often add very useful functionality to your instrument. Most of these elements are a direct result of customer feedback so if you have an idea for a utility element, let us know!

15.1. Relay

This element is included with all Snap-Master modules.

The Relay element uses the value of an incoming signal to effectively connect and disconnect data pipes at run time. Think of the Relay element as a data driven switch to determine what data is passed to downstream elements. When the "switch" is activated, then all data from the selected channels are sent down the pipe to the rest of the instrument (with a new element letter, but the same channel number).

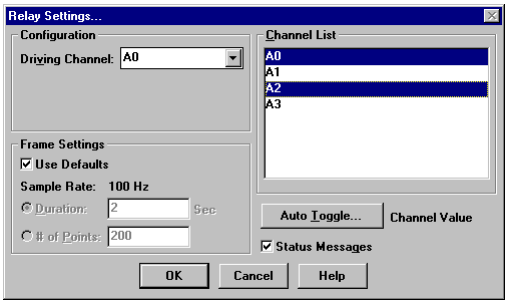


Figure 15-1 Relay Settings

NOTE: When using the Relay element, you must pay special attention to how your instrument is configured. As a general rule, you should only put Output elements (Display, Disk Out, etc.) after the Relay element. The only times you can put Analysis elements after the Relay is if the Relay element will be triggered at least once for every frame on the Driving Channel. If the Relay element does not trigger before the end of the Driving Channel's frame, some Analysis elements piped after the Relay might not process their data, new result frames will not be produced, and the instrument can only be stopped manually. In these cases, you will need to restructure your instrument so all Analysis processing occurs before the Relay element and the Relay passes only the results.

Configuration

The Driving Channel setting for this element determines which channels with a given letter description are available for the Channel list. When you select a driving channel, all channels using the same element letter can activated using this element. To automatically switch channels from more than one element letter (such as more than one A/D element), you will need to use multiple Relay elements or combine the elements into one element letter using Analysis.

Frame Settings

The output channels from the Relay element has their own frame characteristics, but the Frame Settings are based upon those of the Driving Channel. The Sample Rate is always the same as the Driving Channel's sample rate, but the Duration of the frame can be changed. This allows you to operate on smaller sections of data than the entire frame.

To use the same frame duration as the Driving Channel, select the Use Defaults checkbox. To create "sub-frames," turn off the Use Defaults check box and enter either the new Duration or # of Points. (If the Driving Channel reaches the end of its frame before the Relay element's output frame is completed, the Relay element appends zeros to complete the frame.)

Channel List

Channels which are highlighted in the Channel List are passed through when the Relay is activated. The element letter for the output channels is the element letter of the Relay element and the channel number is the same number as shown in the Channel List.

Auto Toggle Settings

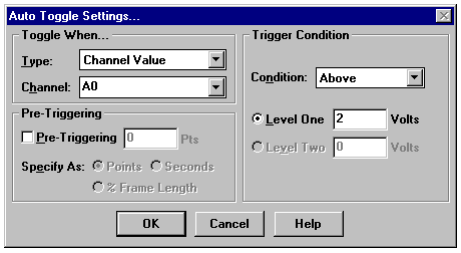


Figure 15-2 Auto Toggle Settings

Toggle When

The Toggle When Type setting determines the criteria used to activate the Relay element so it activates and passes data to other elements. The Channel Value selection uses the Channel and Trigger Condition settings to emulate an analog trigger (like the one used by the Analog Input element). The DDE Command selection activates the Relay element when a *ToggleNow* command is sent to the Element. Refer to Appendix D for more information on using DDE commands with Snap-Master.

Pre-Triggering

Pre-Triggering — When selected, specifies the amount of data included in the data frame that occurred immediately before the trigger condition was satisfied.

Specify As — Selects if the Pre-Triggering amount is specified as **Points**, **Seconds** (or X-axis units), or **% Frame Length**. By specifying a Pre-Trigger length of the entire frame (or 100%), it is possible to set up a "Trigger To Stop" condition. With this setting, the data will not be available until after the frame is acquired and the trigger condition is satisfied.

Trigger Condition

Condition — Specifies the signal characteristic which generates a positive trigger.

Condition	# Levels	Description
Above	1	Trigger occurs when the channel data is above Level One
Below	1	Trigger occurs when the channel data is below Level One
Inside	2	Trigger occurs when the channel data is between Level One and Level Two
Outside	2	Trigger occurs when the channel data is outside both Level One and Level Two
Positive Slope	1	When Level One is selected, the Trigger occurs when the previous channel data point is below Level One and the current channel data point is above Level One
	2	When Level Two is selected, the Trigger occurs when the previous channel data point is below Level One and the current data point is above Level Two
Negative Slope	1	When Level One is selected, the Trigger occurs when the previous channel data point is above Level One and the current channel data point is below Level One
	2	When Level Two is selected, the Trigger occurs when the previous channel data point is above Level One and the current data point is below Level Two

Level 1
Level 2 — Specifies the levels for the various trigger conditions.

15.2. Tutorial: Relay

This tutorial shows how to control data flow while the instrument is running using the Relay element. Instead of the A/D Demo we use for most tutorials, we will use the Wave Generator to generate a ramp wave so it is easy to see when the Relay element is triggered.

Building the Instrument

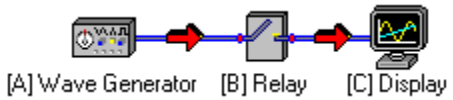


Figure 15-3 Instrument for Relay Tutorial

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place the Wave Generator, Relay, and Display elements in the instrument.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the Wave Generator element to the Relay element, and the Relay element to the Display element.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as RELAY.

Configuring The Wave Generator

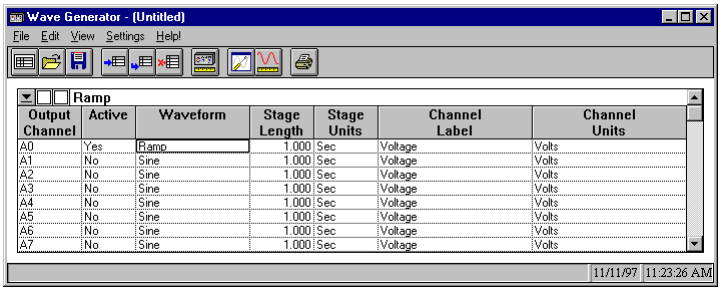

Wave Generator - [Untitled]
File Edit View Settings Help
Ramp
Output Channel | Active | Waveform | Stage Length | Stage Units | Channel Label | Channel Units
A0 | Yes | Ramp | 1.000 | Sec | Voltage | Volts
A1 | No | Sine | 1.000 | Sec | Voltage | Volts
A2 | No | Sine | 1.000 | Sec | Voltage | Volts
A3 | No | Sine | 1.000 | Sec | Voltage | Volts
A4 | No | Sine | 1.000 | Sec | Voltage | Volts
A5 | No | Sine | 1.000 | Sec | Voltage | Volts
A6 | No | Sine | 1.000 | Sec | Voltage | Volts
A7 | No | Sine | 1.000 | Sec | Voltage | Volts
11/11/97
11:23:26 AM

Figure 15-4 Wave Generator Settings

1. Open the Wave Generator Settings table.

2. Position the selection box in the first row, Waveform column and select "Ramp" from the drop down list. By default, this creates a ramp which rises from 0 to 5 volts.

3. Activate the channel by selecting the first row, Active column and selecting *Yes* from the drop down list.

4. Close the Wave Generator element by selecting the File menu, Close Wave Generator command.

Setting Up The Relay

1. Open the Relay Settings dialog box by double clicking on the Relay element.

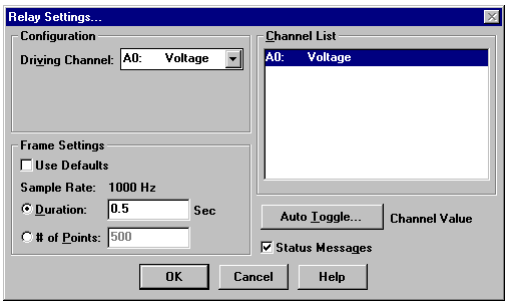


Figure 15-5 Relay Settings

2. Set the Driving Channel to A0.

   This lets us select any channels with the element letter A in the Channel list.

3. Turn off the Use Defaults checkbox.

   For our example, we are only going to grab a small part of the waveform to illustrate the Relay element's ability to extract chunks of data.

4. Set the Duration to 0.5 seconds.

5. Select A0 from the channel list.

   Only channels that are highlighted in the Channel List are passed once the Relay element is activated.

Specifying The Auto Toggle Settings

1. Press the Auto Toggle button.

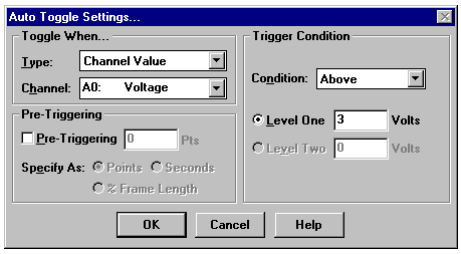


Figure 15-6 Auto Toggle Settings

2. Select Channel Value from the Type combo box.

   This means that the value of the Channel and the Trigger Condition determines when the Relay element is activated.

3. For the Trigger Condition, select Above.

4. Set the Level One value to 3 volts.

5. Press the OK button to close the Auto Toggle Settings dialog box.

6. Press the OK button to close the Relay Settings dialog box.

Running the Instrument

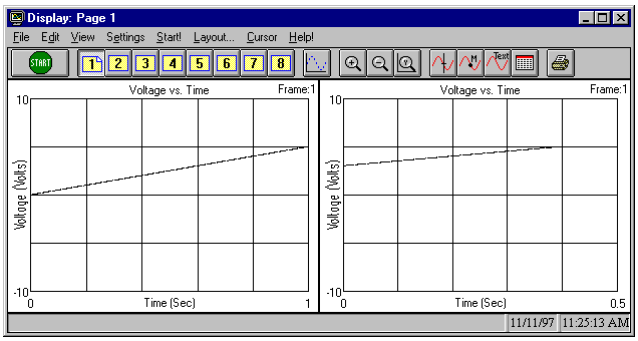


Figure 15-7 Results of Relay Tutorial

When you run the instrument, the original ramp wave (channel A0) is displayed in the left Y-T plot and the Relay output (channel B0) in the right Y-T plot. (If no plots appear, then you have Auto Layout turned off. Either change the Auto Layout method with the Options menu, Default Settings command or add plots in the Display Layout table.)

15.3. Thermocouple Linearization

This element is included with the Data Acquisition Module.

The Thermocouple Linearization element (or TCLinear) provides a simple method for linearizing B, E, J, K, N, R, S, and T type thermocouples without using dedicated hardware. Up to 256 channels can be linearized using this element.

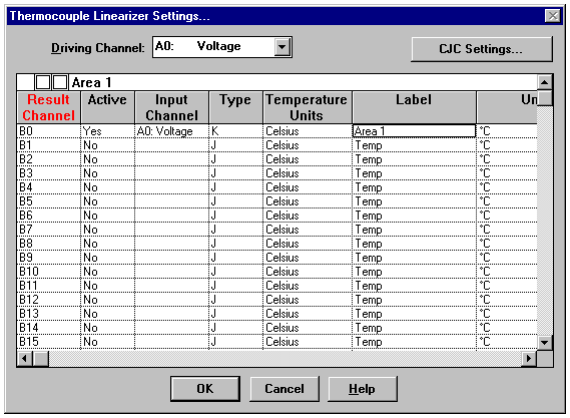

Thermocouple Linearizer Settings...
Driving Channel: A0: Voltage
CJC Settings...
Area 1
Result Channel | Active | Input Channel | Type | Temperature Units | Label | Un
B0 | Yes | A0: Voltage | K | Celsius | Area 1 | °C
B1 | No | | J | Celsius | Temp | °C
B2 | No | | J | Celsius | Temp | °C
B3 | No | | J | Celsius | Temp | °C
B4 | No | | J | Celsius | Temp | °C
B5 | No | | J | Celsius | Temp | °C
B6 | No | | J | Celsius | Temp | °C
B7 | No | | J | Celsius | Temp | °C
B8 | No | | J | Celsius | Temp | °C
B9 | No | | J | Celsius | Temp | °C
B10 | No | | J | Celsius | Temp | °C
B11 | No | | J | Celsius | Temp | °C
B12 | No | | J | Celsius | Temp | °C
B13 | No | | J | Celsius | Temp | °C
B14 | No | | J | Celsius | Temp | °C
B15 | No | | J | Celsius | Temp | °C
OK
Cancel
Help

Figure 15-8 Thermocouple Linearization Settings

The Driving Channel setting for this element determines which channels with a given letter description are available for the Input Channel table selection. When you select a driving channel, all channels using the same element letter can be scaled using this element. To linearize channels from more than one element letter (such as more than one A/D element), you will need to use multiple TCLinear elements.

NOTE: The TCLinear element performs fifth-order polynomials on each data point for the input channels. Due to the complexity of these calculations, keep the sample rate of the Driving Channel low when linearizing a large number of channels. Performance will vary depending on the speed of your computer and the complexity of the instrument.

Table Columns

In the Thermocouple Linearization table, you can edit any column except the Result Channel column (which displays its column heading in red). The following columns are in the table:

Result Channel	Specifies the result channel for the linearization.
Active	Specifies if the linearization is performed for the channel.
Input Channel	Specifies the channel being linearized.
Type	Specifies the thermocouple type of the input channel. The available types are B, E, J, K, N, R, S, and T.
Temperature Units	Specifies the default temperature units for the result channel. When you select an item in this column, the Units column to the right changes automatically to the shorthand form for the units.
Label	Specifies a unique channel name for the result channel.
Units	Specifies the units for the result channel. The contents of this cell will change when a selection is made in the Temperature Units column.

CJC Settings

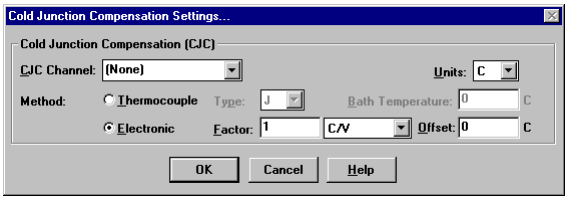


Figure 15-9 Cold Junction Compensation Settings

The CJC (Cold Junction Compensation) settings defines which channel is used as the reference point for all temperature calculations used by the TCLinear element. The Units specifies the temperature units used to define the CJC calculations.

There are two types of support CJC: Thermocouple or Electronic. The Type of thermocouple is selected, along with the current Bath Temperature of the thermocouple. For an Electronic CJC, enter the Factor (along with corresponding scale) and the Offset values.

15.4. Tutorial: Thermocouple Linearization

These tutorials shows how to linearize one thermocouple channel using the TCLinear element. Instead of the A/D Demo we use for most tutorials, we will use the Wave Generator element to generate a very low level sine wave, because the TCLinear element normally deals with signals on the millivolt level.

Building the Instrument

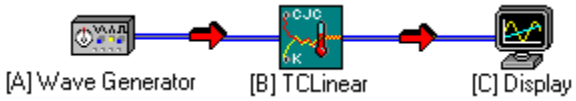


Figure 15-10 Instrument for TCLinear Tutorial

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place the Wave Generator, TCLinear, and Display elements in the instrument.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the Wave Generator element to the TCLinear element, and the TCLinear element to the Display element.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as MULTFRME.

Configuring The Wave Generator

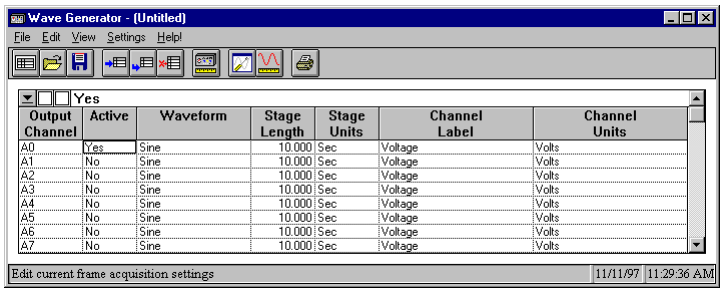

Wave Generator - (Untitled)
File Edit View Settings Help!
Yes
Output Channel
Active
Waveform
Stage Length
Stage Units
Channel Label
Channel Units
A0 Yes Sine 10.000 Sec Voltage Volts
A1 No Sine 10.000 Sec Voltage Volts
A2 No Sine 10.000 Sec Voltage Volts
A3 No Sine 10.000 Sec Voltage Volts
A4 No Sine 10.000 Sec Voltage Volts
A5 No Sine 10.000 Sec Voltage Volts
A6 No Sine 10.000 Sec Voltage Volts
A7 No Sine 10.000 Sec Voltage Volts
Edit current frame acquisition settings
11/11/97
11:29:36 AM

Figure 15-11 Wave Generator Settings

1. Open the Wave Generator Settings table.

2. Activate the first channel by selecting the first row, Active column and selecting *Yes* from the drop down list.

3. Open the Frame Settings dialog by pressing the button in the Command Bar or selecting the Settings menu, Frame Settings command.

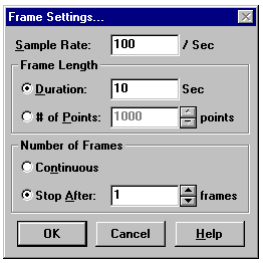


Figure 15-12 Wave Generator Frame Settings

4. Set the Sample Rate to 100 Hz.

5. Set the Duration to 10 seconds.

6. Select the OK button to close the Frame Settings.

7. Open the Waveform Settings dialog by pressing the button in the Command Bar or selecting the Settings menu, Waveform Settings command.

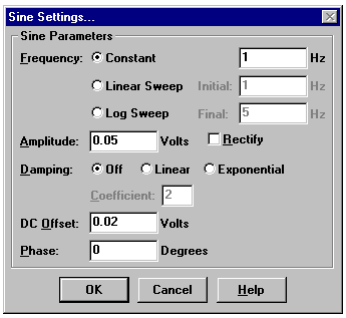


Figure 15-13 Waveform Settings for Sine Wave

8. Set the Amplitude to 0.05 Volts.

9. Set the DC Offset to 0.02 Volts.

10. Select the OK button to close the Sine Settings.

11. Close the Wave Generator element by selecting the File menu, Close Wave Generator command.

Linearizing Thermocouple Channels

1. Open the TCLinear dialog box by double clicking on the element.

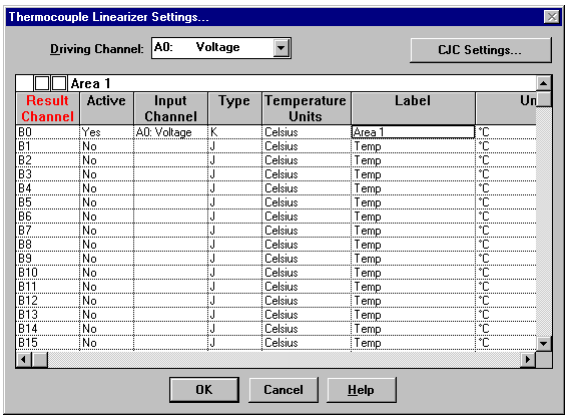

Thermocouple Linearizer Settings...
Driving Channel: A0: Voltage
CJC Settings...
Area 1
Result Channel | Active | Input Channel | Type | Temperature Units | Label | Un
B0 | Yes | A0: Voltage | K | Celsius | Area 1 | °C
B1 | No | | J | Celsius | Temp | °C
B2 | No | | J | Celsius | Temp | °C
B3 | No | | J | Celsius | Temp | °C
B4 | No | | J | Celsius | Temp | °C
B5 | No | | J | Celsius | Temp | °C
B6 | No | | J | Celsius | Temp | °C
B7 | No | | J | Celsius | Temp | °C
B8 | No | | J | Celsius | Temp | °C
B9 | No | | J | Celsius | Temp | °C
B10 | No | | J | Celsius | Temp | °C
B11 | No | | J | Celsius | Temp | °C
B12 | No | | J | Celsius | Temp | °C
B13 | No | | J | Celsius | Temp | °C
B14 | No | | J | Celsius | Temp | °C
B15 | No | | J | Celsius | Temp | °C
OK Cancel Help

Figure 15-14 Thermocouple Linearization Settings

2. Set the Driving Channel to A0.

This lets us scale all channels with the element letter A in the Input Channel column.

3. Position the selection box in the Input Channel column of the first row. Select channel A0 from the list.

4. Position the selection box in the Active column of the first row, then select channel *Yes* from the list.

5. Position the selection box in the Label column of the first row, then enter *Area 1* for the label.

We are not actually measuring any thermocouples in this exercise, so you can select any Type you want (the tutorial will use type J).

Specifying The CJC Settings

1. Press the CJC Settings button.

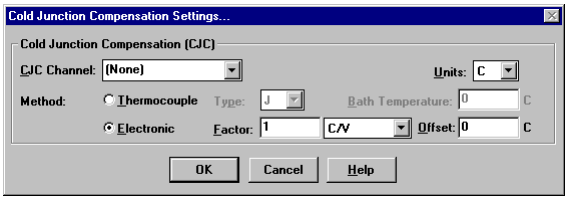


Figure 15-15 Cold Junction Compensation Settings

2. Select Electronic in the CJC Type group.

   Because we do not have an actual CJC channel, we will use an electronic CJC. With a Factor of 1 and an Offset of 0, our “source” data will not be altered.

3. Press the OK button to close the CJC Settings.

4. Press the OK button to close the TCLinear dialog box.

Running the Instrument

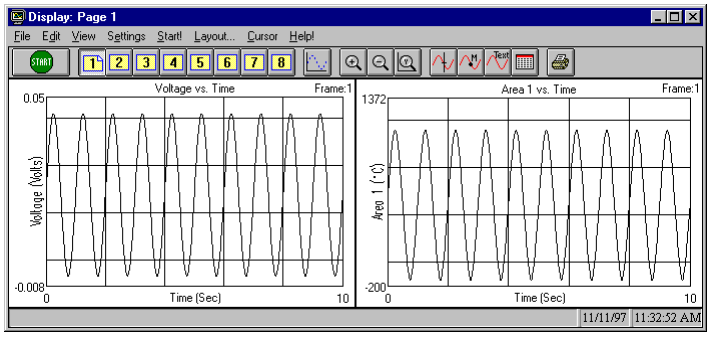


Figure 15-16 Results of TCLinear Tutorial

When you run the instrument, the original data is channel A0, shown on the left (the Y-axis scaling shown was achieved using the , or Auto Scale button). On the right, the equivalent thermocouple data is shown in degrees C. The scaling shown is the default range for the thermocouple type used. When you are measuring actual thermocouples, repeat the exercise replacing the A/D Demo with an actual A/D device.

15.5. Smoothing

This element is included with the Data Acquisition Module.

The Smoothing element provides a simple Low Pass averaging filter, similar to the one found in the Analysis element. For low level signals such as thermocouples which may be noisy, the Smoothing element makes the data more presentable for display and storage purposes.

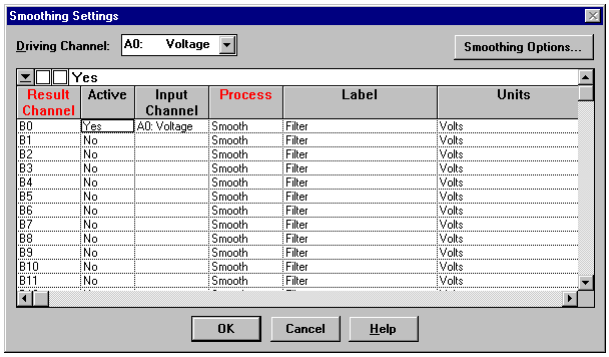


Figure 15-17 Smoothing Settings

The Driving Channel setting determines which channels are available for the Input Channel table selection. When you select a driving channel, all channels using the same element letter can be smoothed using this element. To smooth channels from more than one element letter (such as more than one A/D element), you will need to use multiple Smoothing elements.

Table Columns

In the Smoothing Settings table, you can edit any column except the Result Channel and Process columns (which display their column headings in red). The following columns are in the table:

Result Channel	Specifies the result channel for the smoothing.
Active	Specifies if smoothing is performed on the channel.
Input Channel	Specifies the channel being smoothed.
Process	Specifies the process used by the element.
Label	Specifies a unique channel name for the result channel.
Units	Specifies the units for the result channel.

Smoothing Options

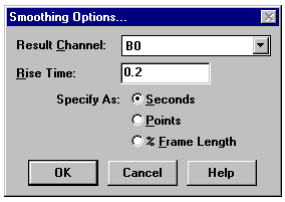


Figure 15-18 Smoothing Options

The Smoothing Options dialog defines the filter rise time for each channel. This setting also affects the fall time for the filter. (Because the filter uses the equivalent of a block averaging filter, the Rise Time setting actually controls the amount of data used for the block - a larger rise time uses more data points for the block size). Each channel can be configured with a different rise time by selecting each channel in the Result Channel list.

15.6. Tutorial: Smoothing

This tutorial shows how to smooth two channels using the Smoothing element. Instead of the A/D Demo we use for most tutorials, we will use the Wave Generator element to generate a square wave.

Building the Instrument

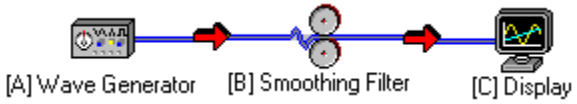


Figure 15-19 Instrument for Smoothing Tutorial

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place the Wave Generator, Smoothing, and Display elements in the instrument.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the Wave Generator element to the Smoothing element, and the Smoothing element to the Display element.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as SMOOTH.

Configuring The Wave Generator

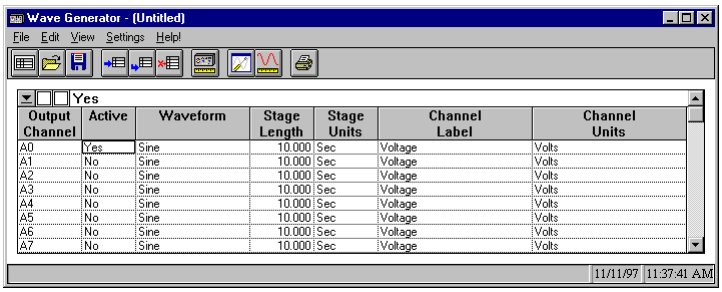

Wave Generator - [Untitled]
File Edit View Settings Help!
Yes
Output Channel | Active | Waveform | Stage Length | Stage Units | Channel Label | Channel Units
A0 | Yes | Sine | 10.000 | Sec | Voltage | Volts
A1 | No | Sine | 10.000 | Sec | Voltage | Volts
A2 | No | Sine | 10.000 | Sec | Voltage | Volts
A3 | No | Sine | 10.000 | Sec | Voltage | Volts
A4 | No | Sine | 10.000 | Sec | Voltage | Volts
A5 | No | Sine | 10.000 | Sec | Voltage | Volts
A6 | No | Sine | 10.000 | Sec | Voltage | Volts
A7 | No | Sine | 10.000 | Sec | Voltage | Volts
11/11/97 11:37:41 AM

Figure 15-20 Wave Generator Settings

1. Open the Wave Generator Settings table.

2. Activate the first channel by selecting the first row, Active column and selecting *Yes* from the drop down list.

3. Open the Frame Settings dialog by pressing the button in the Command Bar or selecting the Settings menu, Frame Settings command.

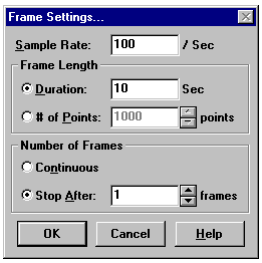


Figure 15-21 Wave Generator Frame Settings

4. Set the Sample Rate to 100 Hz.

5. Set the Duration to 10 seconds.

6. Select the OK button to close the Frame Settings.

7. Open the Waveform Settings dialog by pressing the button in the Command Bar or selecting the Settings menu, Waveform Settings command.

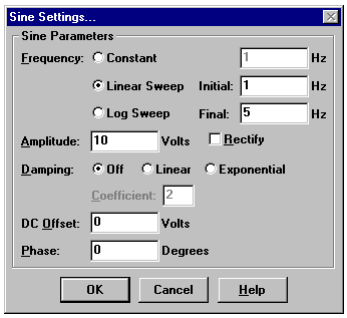


Figure 15-22. Waveform Settings for Swept Sine Wave

8. Select the Linear Sweep mode.

9. Select the OK button to close the Sine Settings.

10. Close the Wave Generator element by selecting the File menu, Close Wave Generator command.

Configuring The Smoothing Element

1. Open the Smoothing dialog box by double clicking on the element.

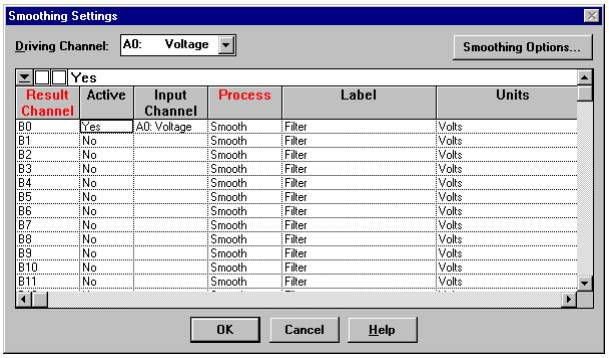

Smoothing Settings
Driving Channel: A0: Voltage
Smoothing Options...
Yes
Result Channel | Active | Input Channel | Process | Label | Units
B0 | Yes | A0: Voltage | Smooth | Filter | Volts
B1 | No | | Smooth | Filter | Volts
B2 | No | | Smooth | Filter | Volts
B3 | No | | Smooth | Filter | Volts
B4 | No | | Smooth | Filter | Volts
B5 | No | | Smooth | Filter | Volts
B6 | No | | Smooth | Filter | Volts
B7 | No | | Smooth | Filter | Volts
B8 | No | | Smooth | Filter | Volts
B9 | No | | Smooth | Filter | Volts
B10 | No | | Smooth | Filter | Volts
B11 | No | | Smooth | Filter | Volts
OK Cancel Help

Figure 15-23 Thermocouple Linearization Settings

2. Set the Driving Channel to A0.

This lets us scale all channels with the element letter A in the Input Channel column.

3. Position the selection box in the Input Channel column of the first row. Select channel A0 from the list.

4. Position the selection box in the Active column of the first row, then select channel *Yes* from the list.

Specifying The Rise Time

1. Press the Smoothing Options button.

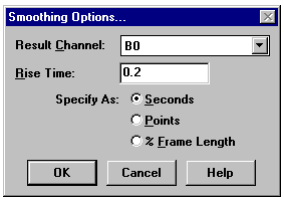


Figure 15-24 Smoothing Options

2. Select channel B0 from the Result Channel list.

   We are going to set the rise time for the filter used by result channel B0. For our 1 Hz square wave (the default used by Wave Generator), let's pick a rise time that is sufficiently long so we can view the effects of the filter.

3. Set the Rise Time to 0.2.

4. Set the Specify As to Seconds.

5. Press the OK button to close the Smoothing Options dialog box.

6. Press the OK button to close the Smoothing dialog box.

7. Save the instrument with the button or select the File menu, Save Instrument command.

Running the Instrument

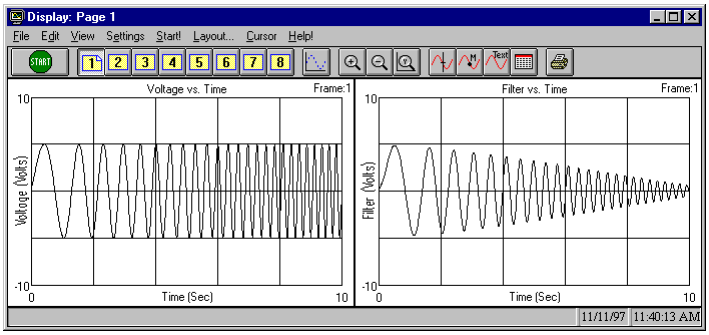


Figure 15-25 Results of Smoothing Tutorial

When you run the instrument, the original swept sine is channel A0 and the filtered result is B0. As you can see, the filtered result tapers off in amplitude as the frequency of the original signal increases. is more trapezoidal due to the rise time setting of the smoothing filter. If you set a shorter rise time, you will see less effect at higher frequencies because the amount of transition within the moving average window (or the Rise Time setting) is less, so the averaging does not cancel out as much information.

15.7. Histogram

This element is included with both the Waveform Analyzer and Frequency Analyzer Modules.

The Histogram element counts the number of instances a specified event occurs. The element can count events occurring in either the X- or Y- axis. In addition, the element also sorts data into bands, bins, intervals, or ranges (this text uses the term *bins* to represent all of these terms). The main uses for the element include histograms and band analysis.

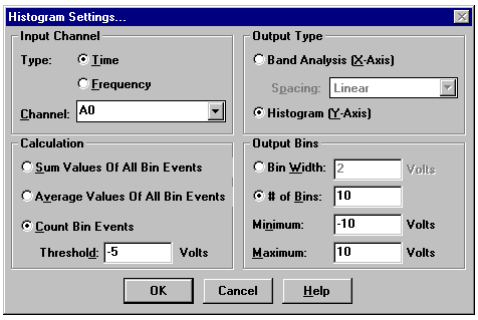


Figure 15-26 Histogram Settings Dialog Box

When you calculate a new channel with this element, the output is channel 0 using the element letter of the Histogram element. When the channel is plotted with the Display element, the "Histogram" plot type is automatically selected. In addition, Histogram results cannot be stored to disk with the Disk Out element.

Input Channel

Specifies either the **Time** or **Frequency** domain channel being analyzed. Note that the contents of the Channel list only contains channels of the specified type.

Calculation

Sum Values	Adds the value of each data point within a bin
Average Values	Sums all data values in each bin and divides each by the number of events to produce an average value per bin
Count Bin Events	Counts the number of data points above the specified **Threshold**.

Output Type

Band Analysis — Divides the X-axis into the specified **Bin Width** or **Number of Bins** (except for Octave Band Analysis) and performs the calculation on each bin.

The standard Spacing setting is Linear, which divides the bin width equally among all bins. When a Frequency channel is specified in the Input Channel group you can perform Octave Band Analysis, which divides each bin into a octaves (which is a doubling in frequency), or octave divisions. The available octave divisions are **1 Octave**, **1/3 Octave**, **1/5 Octave**, **1/8 Octave**, and **1/12 Octave**.

Histogram — Divides the Y-axis into the specified **Bin Width** or **Number of Bins** and performs the calculation on each bin.

Output Bins

Bin Width — When selected, specifies the incremental range for each bin.

# of Bins — When selected, specifies an absolute number of bins.

Minimum
Maximum — Specifies the range for the calculation.

Histogram

Settings

Input Channel: Time

Calculation: Counting

Output Bin: Histogram

The traditional histogram counts the number of times data occurs within a certain Y-axis range (such as voltage). Each Y-axis range of input data is represented by a bin on the X-axis of the output plot. The Counting calculation counts the number of values exceeding the Threshold, and plots the count on the Y-axis as the output for each bin.

Band Analysis

Settings

Input Channel: Frequency

Calculation: Averaging

Output Bin: Band Analysis

Spacing: Linear

Band Analysis plots the average amplitude, power, or energy of a particular frequency range on the Y-axis. The amplitude, power and energy values of the input data are calculated using the FFT. Each frequency range is represented by a bin on the X-axis in the output plot.

Octave Band Analysis

Settings

Input Channel: Frequency

Calculation: Averaging

Output Bin: Band Analysis

Spacing: 1 Octave, 1/3 Octave, etc.

Octave Band Analysis is like Band Analysis, except the bins are divided into octaves instead of linearly.

15.8. Tutorial: Histogram

Building the Instrument

Figure 15-27 Instrument for Histogram Tutorial

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place the A/D Demo, Histogram, and Display elements in the instrument.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the A/D Demo element to the Histogram element, and the Histogram element to the Display element.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as HISTO.

Performing A Histogram Calculation

1. Open the A/D Demo Settings by double clicking on the element.

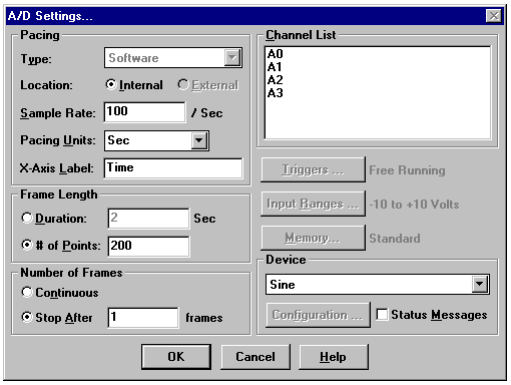


Figure 15-28 A/D Demo Settings

2. Change the Number of Frames to Stop After 1 frame.

3. Press the OK button to close the A/D Demo Settings.

4. Open the Histogram Settings dialog.

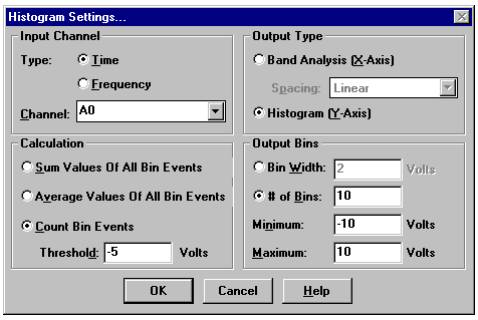


Figure 15-29 Histogram Settings

5. Set the Input Channel to A0.

   The A/D Demo outputs time-based data, so make sure the Time radio button is selected, then select channel A0 from the Channel list.

6. Set the Calculation to Count Bin Events with a Threshold of -5.

   Traditional histograms count the number of data points within a certain range, so we must specify the Count calculation. Because the A/D Demo element has an output of ±5 Volts, set the Threshold to -5 Volts and the minimum and maximum In and Output bins to - and + 5 volts.

7. Press the OK button to close the Histogram Settings dialog.

8. Open the Display window, then open the Display Layout with the Layout menu.

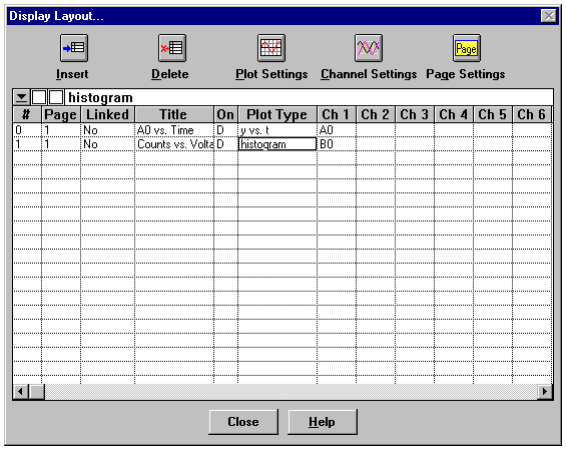

Display Layout...
Insert
Delete
Plot Settings
Channel Settings
Page Settings
histogram
Page Linked Title On Plot Type Ch 1 Ch 2 Ch 3 Ch 4 Ch 5 Ch 6
0 1 No A0 vs. Time D y vs. t A0
1 1 No Counts vs. Volts D histogram B0
Close
Help

Figure 15-30 Display Layout

Depending on how you have Auto Layout configured, you may need to delete the plots for channels A1, A2, and A3. Highlight the plots you do not need, then press the Delete button .

Notice that the Plot Type for channel B0 (the output of Histogram element) defaults to "Histogram". If you try to change the Plot Type, a warning dialog box will appear.

Before we close the Display Layout, we need to configure the Y-Axis for the plot of B0 for a maximum of 50 data points.

9. Position the selection box in the second row, then press the Plot Settings button .

10. Turn off the Default Scale check box in the Y-Axis Settings group, then change the Maximum to 50.

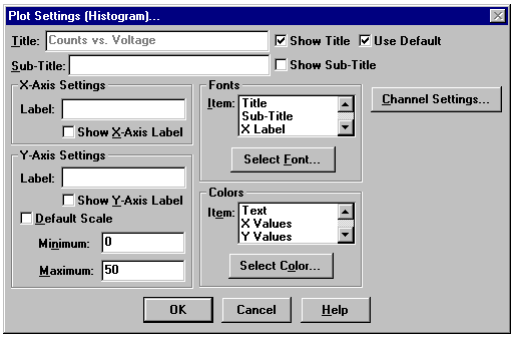


Figure 15-31 Histogram Plot Settings

11. Press the OK button to close the Plot Settings dialog, then press the Close button to close the Display Layout dialog.

12. Switch to the Snap-Master window and save the instrument with the button or with the File menu, Save command.

Running the Instrument

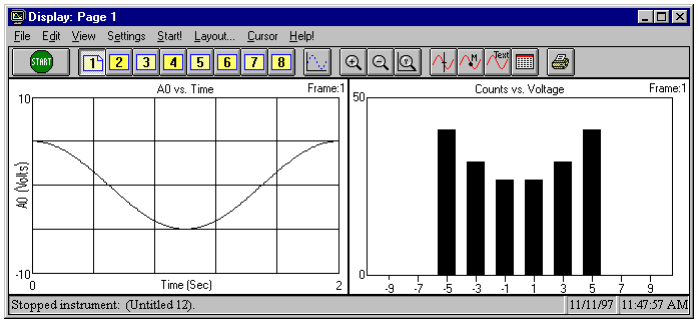


Figure 15-32 Results of Histogram Tutorial

When you run the instrument, the data in the plot of B0 appears as data comes in from the A/D Demo. The Y-axis shows the number of data points contained within each voltage range. In this case, each bin represents a 2 volt range from -10 to +10 Volts. This is due to our settings in the Event Counting and Sorting element (Total Range = Maximum - Minimum, and the Range per Bin = Total Range / # of Bins). If you were to count the total number of data points, there would be 200 (because the Sampling Rate of the A/D Demo is 100 per second and the frame size is 2 seconds).

15.9. MultiFrame

This element is included with both the Waveform Analyzer and Frequency Analyzer Modules.

The Multiple Frame element performs a running sum or average across a specified number of data frames. The input data can be either time-based or frequency-based. The output is a single channel (channel 0, using the element letter of the MultiFrame element) with the same sample rate and number of points per frame as the input channel.

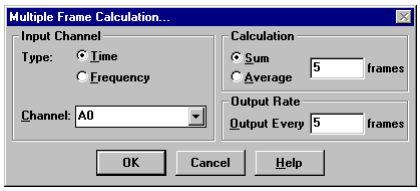


Figure 15-33 Multiple Frame Calculation Dialog Box

Input Channel

Specifies either the **Time** or **Frequency** domain channel being analyzed. Note that the contents of the Channel list only contains channels of the specified type.

Frame Calculation Type

Sum	Continuously sums each point in the frame until the number of frames specified have been processed, at which time the calculation restarts.
Average	Continuously averages each point in the frame until the number of frames specified have been processed, at which time the calculation restarts.

Output Every

Specifies the rate at which a frame is output from the Multiple Frame element. A value of 1 means that a result is produced every frame. For large calculations, you can reduce the number of output frames by raising this number. The Output Every *n* frames value must be less than the number of frames that are operated on, as specified in the Frame Calculation Type group.

15.10. Tutorial: MultiFrame

This tutorial shows how to add five frames of data and output the result as either a single frame of data or as five separate frames.

Building the Instrument

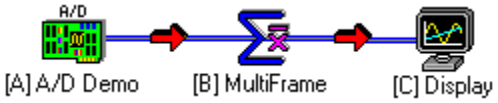


Figure 15-34 Instrument for MultiFrame Tutorial

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place the A/D Demo, MultiFrame, and Display elements in the instrument.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the A/D Demo element to the MultiFrame element, and the MultiFrame element to the Display element.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as MULTFRME.

Summing Five Frames Into One Frame

1. Open the A/D Demo Settings dialog box.

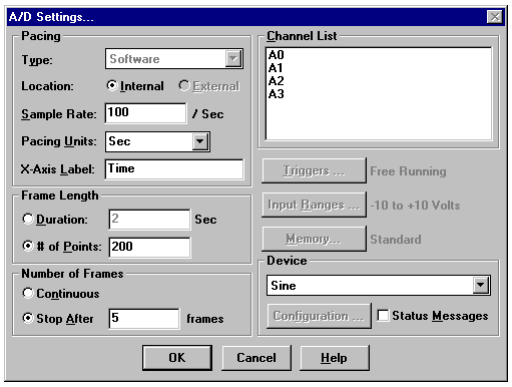


Figure 15-35 A/D Demo Settings

2. Set the Number of Frames to Stop After 5 frames.

3. Select the OK button to close the A/D Demo Settings.

4. Open the MultiFrame Calculation dialog box.

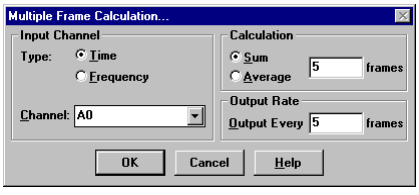


Figure 15-36 MultiFrame Calculation Settings

5. Set the Channel to A0.

   Because the A/D Demo outputs time-based data, make sure the Time radio button is activated, then select channel A0 from the Channel list.

6. Set the Calculation Type to Sum 5 frames.

7. Set the Output Rate to Output Every 5 frames.

   When you run the instrument with these settings, you will see data for channel A0 every frame, but data will be displayed for channel B0 (the output of the MultiFrame element) only on the fifth frame.

8. Press the OK button to close the MultiFrame dialog box.

9. Open the Display window, then open the Display Layout dialog box with the Layout menu.

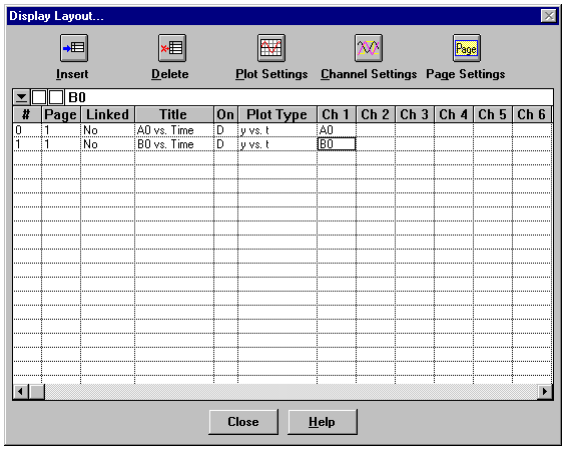

Display Layout...
Insert
Delete
Plot Settings
Channel Settings
Page Settings
B0
Page Linked Title On Plot Type Ch 1 Ch 2 Ch 3 Ch 4 Ch 5 Ch 6
0 1 No A0 vs. Time D y vs. t A0
1 1 No B0 vs. Time D y vs. t B0
Close
Help

Figure 15-37 Display Layout

Depending on how you have Auto Layout configured, you may need to delete the plots for channels A1, A2, and A3. Highlight the plots you do not need, then press the Delete button .

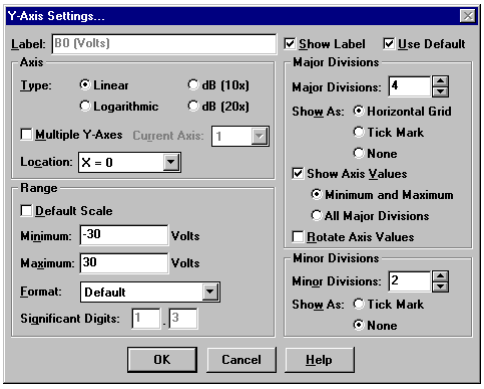


Figure 15-38 Y-Axis Settings for MultiFrame Output

Before we close the Display Layout, we need to configure the Y-Axis for the plot of B0 with a minimum of -30 and a maximum of 30.

10. Position the selection box in the second row, then press the Plot Settings button .

11. Press the Y-Axis Settings button.

12. Turn off the Default Scale check box, then change the Minimum to -30 and the Maximum to 30.

13. Press the OK button to close the Y-Axis Settings dialog, press the OK button to close the Plot Settings dialog, then press the Close button to close the Display Layout dialog.

14. Switch to the Snap-Master window and save the instrument with the button or with the File menu, Save command.

Running the Instrument

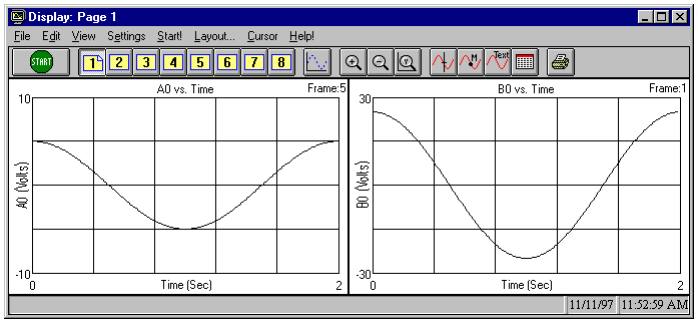


Figure 15-39 Results of MultiFrame Tutorial

When you run the instrument, the data in the plot of A0 appears in all frames, and the data for B0 appears in the fifth frame only. This is due to the Output Every 5 frames setting in the Multiple Frame element. If you set the value to Output Every 1 frame, then you will see data in B0 every frame. By outputting the data every fifth frame, the total amount of data plotted has been reduced from five frames to one frame.

Outputting All Five Frames

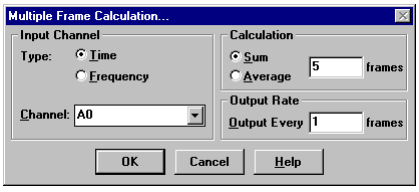


Figure 15-40 Output Data Every Frame

To see the difference the Output Every setting makes, reopen the MultiFrame Calculation dialog and change the value to 1. When you run the instrument this time, the output channel B0 looks different for each frame. For frame 1 B0 looks the same as A0. For frame 2 B0 is the sum of the first two frames of A0. Frame 3 of B0 is the sum of the first three frames of A0, and so on until the final frame which looks the same as in the previous section.

If you wish to experiment further, try changing the number of frames in the A/D Demo to Stop After 10. The output of B0 will look the same as above for the first five frames. On frame 6, B0 starts over and is equal to frame 6 of A0. Frame 7 of B0 equals the sum of frames 6 and 7 of A0, etc.

Chapter 16. IndustrialSQL

16.1. Connecting to the Server 16-1
16.2. IndustrialSQL In Settings 16-2
16.3. Tutorial: Using The IndustrialSQL In Element 16-4

The IndustrialSQL In element makes Snap-Master a client application that allows you to query tags from the IndustrialSQL Server database and use them as Snap-Master channels. Once you have added tags to Snap-Master, you can analyze and plot the data using other Snap-Master elements.

Before using this element, you must install and configure IndustrialSQL Server and the SQL Server ODBC driver. Please refer to the documentation provided with IndustrialSQL Server for more information on installation.

NOTE: This Snap-Master element can only be used on the Windows 95 or Windows NT platforms.

This element only operates on Historical data; "live" data can not be imported using this element. Use the DDE In element to access live data from other FactorySuite applications.

16.1. Connecting to the Server

You must connect to an IndustrialSQL Server database before data can be retrieved. The first time you attempt to open the IndustrialSQL In element in an instrument or run the instrument, you are asked to connect to an IndustrialSQL Server database. This connection is maintained until you exit Snap-Master.

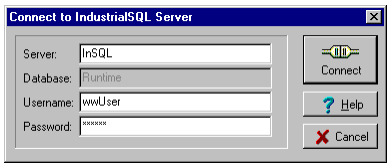


Figure 16-1 IndustrialSQL In Login

Server	Name of the IndustrialSQL Server to which you want to connect.
Database	Name of the database to which you want to connect. (This option may appear dimmed.)
Username	User name for your logon account.
Password	Password for the logon account.

NOTE: A user account is comprised of the Login ID and password. A user account must be associated with the right to retrieve data, or else the log on will fail. For more information on user accounts, contact your system administrator.

The first time you make a connection to an IndustrialSQL database, you are asked to verify the ODBC settings. You should only enter or modify the Network Address - all other settings for the ODBC DSN (Data Source Name) are created automatically.

Figure 16-2 ODBC Settings for Snap-Master to IndustrialSQL DSN

16.2. IndustrialSQL In Settings

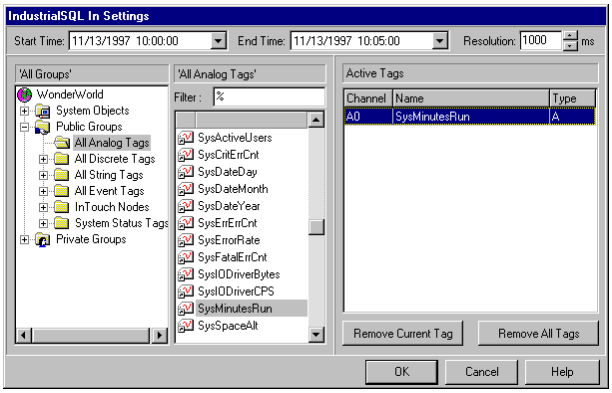


Figure 16-3 IndustrialSQL In Settings

The IndustrialSQL In Settings dialog specifies which tags are activated for use by Snap-Master. The format and usage of this dialog is similar to the IndustrialSQL Trend program, except that instead of dragging tags to a trend plot you double click to send them to the Active Tags table.

Before using this element, you must install the IndustrialSQL Server and configure the ODBC drivers on the client. For more information, please refer to the documentation accompanying IndustrialSQL.

Start Time and End Time

The Start Time and End Time controls allow you to set start and end dates for the data requested. To set a start date or end date:

1. Click the button at the right of the control.

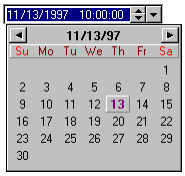


Figure 16-4 Start and Stop Date Selection

2. Select a date from the calendar by clicking on it. Use the and buttons to move forward or backward in the calendar.

3. Select a time using the arrows. You must insert your cursor in the section of the time stamp that you want to control with the arrows.

Resolution

The Resolution setting sets the time spacing (in milliseconds) for the data in the tags. The Sample Rate is calculated for this element based on this setting. The maximum resolution that can be selected is 1 millisecond.

As you request higher resolutions, the data transfer takes longer to retrieve the data from the IndustrialSQL database. Once the data has been sent to Snap-Master, new requests are not made until you restart the instrument.

Tree View

The tree view is a graphical representation of the namespaces in the database. Each object in the database is listed as an item in the tree view. The tree view consists of two panes. The left-most pane shows the overall tree view (groups). When you select an object in the left pane of the tree view, all objects lower in the namespace hierarchy will appear in the right pane (leaves).

To search for a tag in the right pane of the tree view, type the tagname in the Filter Mask box. As you type the desired tagname, tags starting with the letters you have typed will immediately appear in the tree view.

The tree view displays all objects that are visible to all clients. This grouping is also called the public namespace.

You can navigate in the tree view as you would any typical Windows based browsing application.

Active Tags

The tag list displays information about all tags included from the database and their status in Snap-Master. To include a tag in the instrument, double click on an item in the tree view. The tag is then added to the end of the list and a new channel is created.

If you remove a tag from the Active Tag list using the Remove Current Tag button, the channel numbers are renumbered to always be contiguous. If you are using a specific tag as a channel in downstream elements (such as Analysis or Display), you will need to manually change those elements to reflect the change in the tag to channel numbering.

The table columns in the Active Tags table are:

Channel	Specifies the Snap-Master channel designation for the tag.
Name	Specifies the tag name of the channel. This is also used to set the Label in Snap-Master for the channel.
Type	Specifies the type of data stored in the tag. In Snap-Master, you can only read numeric type data.

16.3. Tutorial: Using The IndustrialSQL In Element

This tutorial discusses how to access data from and IndustrialSQL Server database. Before continuing the tutorial, make sure that the IndustrialSQL Server is running and that you have the proper access rights to the database.

Building the Instrument

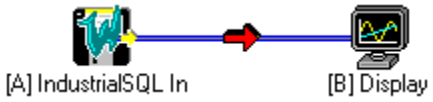


Figure 16-5 Instrument for IndustrialSQL In Tutorial

1. Create a new instrument with the button or select the File menu, New Instrument command in the Snap-Master workspace.

2. Place the IndustrialSQL In and Display elements in the instrument.

3. Activate Pipe Mode with the button or select the Element menu, Pipe Mode command.

4. Connect the IndustrialSQL In element to the Display element.

5. Turn off Pipe Mode with the button or select the Element menu, Pipe Mode command.

6. Save the instrument with the button or select the File menu, Save Instrument As command. Save the instrument as ISQLIN.

Connecting to the IndustrialSQL Server Database

1. Open the IndustrialSQL In Settings by double clicking on the element.

2. Login to the database using the appropriate Server, Database, Username, and Password entries.

   If the connection is successful, you will return to the IndustrialSQL In Settings dialog and the Database Connect button will appear pressed in. You must be connected to the database before continuing the tutorial.

Activating A Tag

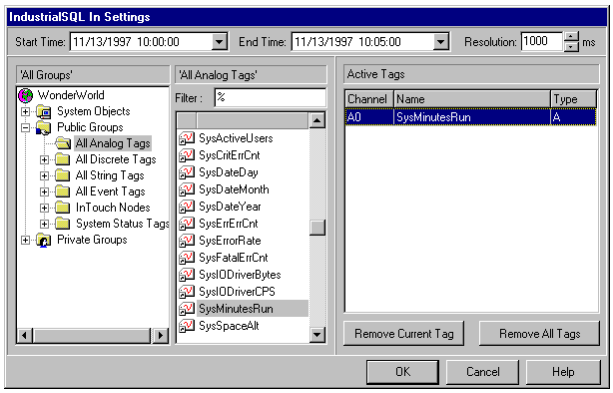


Figure 16-6 IndustrialSQL In Settings

1. In the tree view, select the All Analog Tags group and locate the SysMinutesRun tag.

2. Double click on the SysMinutesRun tag to add it to the Active Tags table.

3. Press OK to close the IndustrialSQL In Settings dialog.

4. Save the instrument with the button.

Running the Instrument

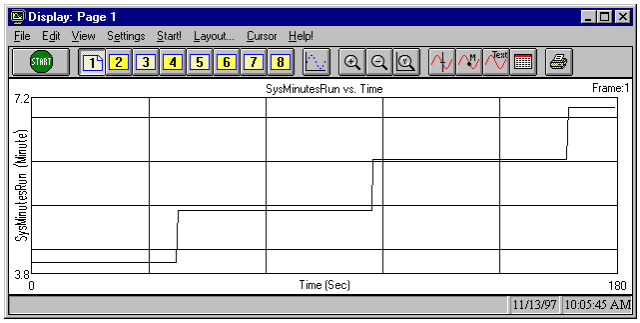


Figure 16-7 IndustrialSQL Data in Snap-Master

When you press the button, all of the data is requested from the database server. There may be a delay before the data is presented on screen depending on the amount of data requested and the amount of traffic on the network.

To scale the data as shown above, press the Auto Y-Scale button.

Appendix A. Glossary

A/D Abbreviation for Analog to Digital Conversion. Reverse of D/A.

A/D Board Receives data from a plug-in A/D (analog-to-digital) converter card. Specifies the sampling rates, acquisition times, and other card options. When this element is placed in an instrument, its name changes to the model of the A/D card.

A/D Demo The A/D Demo element mimics the operation of a plug-in A/D board in Snap-Master.

Acquisition The process by which data is gathered by the computer for analysis or storage.

Active Filter An electronic filter that combines active circuit devices, usually amplifiers with passive circuit elements, such as resistors and capacitors. Active filters typically have characteristics that more closely match ideal filters than do strictly passive filters.

Algorithm A set of rules or detailed plan with a finite number of steps, for solving a problem. An algorithm can be used as a model for a computer program.

Alias Frequency A false or lower frequency component that appears in analog data reconstructed from original data required at an insufficient sampling rate.

Aliasing Occurs when the sampling rate is too low and therefore, higher frequencies appear as lower frequencies. See Nyquist Theorem.

Amplitude Peak measurement of a varying signal.

Analog A continuous signal or process.

Analog to Digital Conversion The process of changing a continuously varying signal into discrete data. Analog voltages are received by the system, converted to digital numbers, then stored or analyzed by the computer.

Analysis Performs near real-time analysis on incoming data using algebra, trigonometry, integration, differentiation, statistics, and curve fitting. The results are output from this element as separate sets of data.

ASCII American National Standard Code for Information Exchange. An ASCII file is a text file where the characters are represented in ASCII codes. ASCII character codes are given in Appendix G of the IBM BASIC manual.

Asynchronous A communications protocol where information can be transmitted at an arbitrary, unsynchronized point in time, without synchronization to a reference timer or "clock."

Background A secondary task performed by the computer in conjunction with the primary or foreground task.

Bandpass Filter A type of filter that allows a band of signal frequencies between two set frequencies to pass while attenuating all signal frequencies outside the bandpass range.

Base Address Defines the location of the input and output ports of the computer used to control computer hardware.

Binary Data file format for Snap-Master that stores raw data using binary numbers.

Bipolar A signal range that includes both positive and negative values.

Bit A unit of computer information equivalent to the result of a choice between two alternatives (as yes or no, on or off, 0 or 1). It is the smallest piece of information in the computer system. I/O boards are typically between 8 to 16 bits. Raise 2 to the power of the number of bits of the board to define resolution, which is the smallest significant number to which a measurement can be determined.

Board A data acquisition board is required to work with Snapshot Storage Scope and Snap-Master Data Acquisition software. The board may include both A/D and D/A capabilities.

Buffer A storage location used for holding information that is to be used at a later time.

Burst Mode A high speed data transfer in which the address of the data is sent followed by back-to-back data words while a physical signal is asserted.

Byte This term refers to eight related bits of information. Eight bits equals one byte.

Channel Specifies the location of a signal going to or coming from the A/D board. A channel is always associated with an element letter.

Click To click with the mouse, press the left mouse button and release.

Close Box Located in the upper left corner of the window. Double clicking on the close box exits the application.

Command Snap-Master element that performs actions based on decisions phrased using IF THEN syntax.

Comment Field Area at the top of a Snap-Master instrument window where the user can enter text about the instrument.

Common-Mode Rejection Ratio (CMR) A measure of an instrument's ability to ignore or reject interference from a voltage common to its input terminals relative to ground. CMR is usually expressed in dB (decibels).

Concurrent Software that can perform more than one task simultaneously.

Configuration This terms refers to the hardware and software set up. They must correspond. The hardware should be changed first and then the software configuration file should be changed to match the hardware changes.

Counter/Timer Hardware that counts digital events or measures the time difference between digital events.

Cursor A cursor allows the user to determine time and amplitude (in engineering units) data while viewing the waveforms.

D/A Abbreviation for Digital to Analog Conversion. Reverse of A/D.

D/A Board Converts digital data into an analog signal, which is output through a plug-in D/A card. This feature is included on some types of A/D cards.

Data Acquisition The collection and recording of information. Snap-Master collects the information using a variety of input sources and records the data to disk when the Disk Out element is included in the instrument.

Data Acquisition Module Snap-Master module which performs data acquisition functions. Data can be acquired using a plug-in A/D board or external hardware. Contact HEM Data for a list of currently supported hardware.

Data Pipes Data pipes transfer information between elements. The elements are said to be "connected" with data pipes. To connect elements together, change to Pipe Mode, which is located in the Element menu.

DDE see Dynamic Data Exchange

Dialog Boxes Used to set up element parameters and to display messages. In order to continue, you must respond by pressing a pushbutton.

Differential Positive and negative inputs each go into separate amplifiers, which improves the noise reduction. Opposite of a single ended input. Requires twice as many amplifiers as single ended inputs.

Digital A signal which has distinct states. Digital computers process data as binary information having either 1 or 0 states.

Digital In Receives digital data from an external source. This feature is sometimes included on a plug-in A/D card.

Digital to Analog Conversion The process of changing discrete data into a continuously varying signal. Common uses are to present the output of a digital computer as a graphic display or as a test stimulus.

Digital Oscilloscope Equipment used to sample the input signal at discrete time intervals and visually analyze data. Differs from the analog oscilloscope which continuously follows an analog voltage. The advantage of the digital oscilloscope is that the data points collected can be used for further analysis as input to other computer programs. The accuracy of the digital oscilloscope is based on the frequency of sampling data.

Digital Out Outputs digital data from the computer to an external destination. This feature is sometimes included on a plug-in A/D card.

Direct Memory Access (DMA) A method of writing data from an A/D board into a predefined memory block. Information is transferred from the computer memory to a device on the bus while the processor does something else. Also one of three methods of transferring data acquisition system measurements to computer memory (the other methods being polling and interrupt).

Disk Drive Refers to either a floppy disk drive, a hard disk drive, or a RAM disk drive.

Disk In Reads data stored in a file on a floppy, hard, or RAM disk. Can input files written in binary or exponential (ASCII) formats, and Snap-Series files.

Disk Out Writes data to a file on a floppy disk, hard disk, or RAM disk. Can write files in binary or exponential (ASCII) formats, or as a Snap-Series binary file.

Display Displays data on the computer monitor. The display options include y-t and y-x plotting, and strip-chart emulation. Up to 10 plots per channel can be displayed on each set of axes.

DMA Channel The DMA channel used by the data acquisition board must not conflict with DOS operations or any other devices in your system.

DOS Disk Operating System. Also refers to the command line based interface of PC compatible machines.

Drag To drag an item, click on it and hold down the mouse button. While holding the mouse button down, move the mouse until the item is at the desired location on the screen. Release the mouse button.

Driver A software routine that translates data to the format required by a particular device.

Dynamic Data Exchange (DDE) An internal Windows method to exchange information between different applications running simultaneously.

Dynamic Range The ratio of the full-scale range (FSR) of a data converter to the smallest difference it can resolve. Dynamic Range (DR) = 2n. "n" is the resolution in bits.

Element Refers to a specific function or piece of hardware. Elements have an associated icon and are located in the Toolbox. For example, the Display element represents the computer monitor where data can be viewed by the user.

Element Letter Identifying letter given to each element when it is placed in the instrument. Used with channels.

Error Message Messages that indicate violations of proper operating procedures.

Expanded Memory Memory outside of the normal PC computer memory area. May be referred to as bank switched memory. This memory type conforms to the Lotus- Intel-Microsoft Expanded Memory Specification (EMS), versions 3.0 and higher. Snap-Master uses Extended Memory, not Expanded Memory.

Expansion Board A plug in circuit board that adds features or capabilities beyond those basic to a computer, such as a data acquisition system expansion board.

Exponential Data file format for Snap-Master that stores raw data using ASCII text.

Extended Memory Memory above 640K that is addressable by the PC as part of the normal memory area of the computer, but is not used by DOS for user programs. Snap-Master and Windows use Extended Memory.

Extension Suffix of the file name. Last three characters following the period in a file name, such as ".xyz". Can be any one, two or three character name.

External Box In The External Box In element is a general element used to represent information that is read from an external hardware device. It is most often used for devices that communicate using the RS-232 or GPIB communication protocols.

External Box Out The External Box Out element is a general element used to represent information that is sent to an external hardware device. It is most often used for devices that communicate using the RS-232 or GPIB communication protocols.

Fast Fourier Transform Calculates the Fast Fourier Transform, power spectra, transfer and coherence functions. The results are output from this element as separate sets of data.

FIFO A First-In-First-Out memory buffer; the first data stored is the first data sent to the acceptor.

File names Windows uses the MS-DOS file system and has the same file naming rules. Filenames can be up to eight characters in length, and include a three character extension.

Filter The Filter function removes unwanted frequency components from incoming data. Data can be input from disk files, acquired using the Data Acquisition Module, or generated using the Waveform Analyzer module. The results are output as a separate set of data.

Floating-Point Numbers Numbers that contain decimal parts or are presented in scientific notation (digits multiplied by a power of 10). Also known as "real" numbers. Integers are a subset of reals containing whole numbers only.

Frame A contiguous set of data.

Frequency Number of times an alternating waveform goes through a complete cycle in one second; measured in Hertz (cycles per second).

Frequency Analysis Module Snap-Master module which performs Fast Fourier Transforms, calculations using complex numbers, and digital filtering. Data can be input from disk files, acquired using the Data Acquisition Module, or generated using the Waveform Analyzer module.

Gain The amplification of a signal, often used on AD boards. Different A/D boards allow for different gains on each channel. Always remember to reference the data to the specific gain of the input channel.

General Analysis Module see Waveform Analyzer Module

General Purpose Interface Bus (GPIB) The standard bus used for controlling electronic instruments with a computer. Also called IEEE-488 bus.

Graphical User Interface (GUI) An intuitive, easy-to-use way of communicating information to and from a computer program by means of graphical screen displays. GUIs can resemble the front panels of instruments or other objects associated with a computer program.

Hardware The physical components of a computer system, such as the circuit boards, plug-in boards, chassis, enclosures, peripherals, cables, etc.

Hexadecimal A numbering system to the base 16.

Icons An icon is a symbolic representation of active applications that are not in their full-window form. For example, to open the Snap-Master program, double click on its icon. Also, each Snap-Master element has an associated icon which acts as an indicator of the element's functions.

IEEE-488 See GPIB.

Impedance Resistance to flow of alternating current; measured in ohms (reactive).

Instrument Window The Instrument window is where elements are connected together with data pipes. Each of the elements settings are accessible by double clicking on their icon in the Instrument Window.

Interrupt A computer signal indicating that the CPU should suspend its current task to service a designated activity. One of three methods for transferring data acquisition measurements to the computer's memory (the other methods being DMA and polling).

Input/Output (I/O) The process of transferring data from or to a computer system including communications channels, operator interface, or data acquisition and control channels.

Linearity The adherence of a device's response to a straight line relationship.

Lists Presents all available options or components. Some lists allow for the selection of multiple items. Lists are represented by a field and a pull down arrow.

Literal Match Token used in the RS-232 element to define a special string of characters that must match the incoming string from the RS-232 equipment. If the string tokens do not match, an error is logged and the RS-232 element stops.

Math Coprocessor Companion processor to the microprocessor. Contains hard coded programs to carry out fast and highly precise floating point operations along with mathematical functions. A coprocessor is recommended for Snap-Master to speed processing time.

Maximize Box Button located in the upper right corner of the window. When the button is an up arrow, clicking on it expands the window to the full screen size. When the button is a double arrow, the window is already maximized and clicking on it will return the window to its previous size and location.

Memory Electronic devices that enable a computer to store and recall information. In its broadest sense, memory refers to any hardware capable of serving that end, e.g., disk, tape, or semi-conductor storage.

Menu Command Buttons Items followed by an exclamation point in the title bar. When selected, these command buttons immediately initiate an action. In contrast, menus must be pulled down and an option selected before an action is initiated.

Menus Menus allow access to Snap-Master functions, commands, and options. Once you select a menu, you can then select the command you want from the menu. If a menu item is grayed, its action is not appropriate at that time. Some menu items are used to indicate a system state, such as on or off, in which case a check mark is used to indicate the current state.

Microsoft Windows Microsoft Windows is a graphically based user interface for PC compatible computers. Windows allows you to run more than one application at a time and transfer information between applications. Snap-Master is a true Windows application, and operates in the Windows environment.

Minimize Box Button located in the upper right corner of the window, to the left of the Maximize Box. If the button exists, it will contain a down arrow. Clicking on the Minimize Box shrinks the window to its associated icon and sends the icon to the bottom of the screen. By double clicking on the icon, the window will be restored to its previous size and location.

Multiplexer (Mux) A set of semiconductors or electromechanical switches with a common output that can select one of a number of input signals.

Multitasking The characteristic of an operating system that allows a processor to perform several operations at once. Windows is a "cooperative" multitasking system.

Nyquist Sampling Theorem States that the sampling rate must be at least twice as a large as the highest frequency of the input signal otherwise aliasing will occur. Aliasing is when frequencies appear that are not in the actual signal.

Passive Filter A filter circuit using only resistors, capacitors, and inductors. (No active devices such as integrated- circuit amplifiers).

PID Proportional, Integral, Derivative. A three mode control algorithm.

Place Holder Token used in the RS-232 element to define a special string of characters that is ignored when Snap-Master interprets the incoming string from an external piece of RS-232 equipment. The length of the Place Holder token is ignored.

Polling A round-robin canvassing of data acquisition inputs synchronized in software to a clock or external trigger. One of three methods of transferring data acquisition measurements to the computer's memory (the others being DMA and interrupt).

Pretriggering The technique used on a data acquisition board to keep a continuous buffer filled with data, so that when the trigger conditions are met, the sample includes the data leading up to the trigger condition.

Pushbuttons Pushbuttons cause an immediate action to be taken. If the pushbutton is active (indicated by a dotted outline around its text), press ENTER to select it. Press TAB to move between pushbuttons.

Radiobuttons Radiobuttons are small circular buttons in dialog boxes and displays that allow you to select an option from a group of mutually exclusive items. Therefore, you can make only one selection at a time in a group of related radiobuttons. Radiobuttons always appear in groups. Use the ARROW keys to move between radiobuttons, then press SPACEBAR to toggle the radiobutton.

Random Access Memory (RAM) Volatile storage (its contents are erased when the computer loses power) in which you can read and write to any desired location. Usually installed as computer chips on the computer's motherboard.

Range The maximum allowable full-scale signal (input or output) that yields a specified performance level.

Read Only Memory (ROM) Computer memory in which data can be routinely read, but written to only using special means when the ROM is manufactured. ROM is used for storing data or programs on a permanent basis.

Real-Time A property of an event or system in which data is processed as it is acquired instead of being accumulated and processed at a later time.

Resistance Temperature Detector (RTD) A metallic probe that measures temperature based upon its coefficient of resistivity.

Resolution The smallest significant number to which a measurement can be determined. For example, a converter with 12- bit resolution can solve 1 part in 4096.

Sample A data point converted by the A/D board from an analog signal to a digital signal. The accuracy of the collection of samples is based on the sampling frequency. The Nyquist Sampling Theorem states that the input signal must be sampled at least twice the frequency of the highest component of interest.

Sample/Hold (S/H) A circuit which acquires and stores an analog voltage on a capacitor for a short period of time.

Scroll Bars Scroll bars become active when there is too much information for one window. The scroll bars enable you to view this information by scrolling the displayed information within the window either up and down (vertical scroll bar), or left and right (horizontal scroll bar).

Sensor The Sensor element integrates a database of the components that measures physical events and converts them to analog electrical signals. Contains specifications, calibration data, and specifies units for the instrument. When an instrument contains the Sensor element and one of the assigned sensors is past its calibration interval, an error message appears in the Status Log.

Shielded Cable A cable with foil or other sheathing around it to stop radio frequency interference and magnetic fields from generating extraneous signals on cable conductors.

Simultaneous Sample/Hold A data acquisition system in which several sample/hold circuits are used to sample a number of analog channels at the same instant. One sample/hold per analog channel is required.

Signal Conditioner The Signal Conditioner element integrates a database of external signal conditioners such as an amplifiers, anti-aliasing filters, etc. Allows control of software programmable units.

Single Ended Setup where all input signals share a common ground connection. This requires only one amplifier per input. Differential inputs are more desirable because they have better noise reduction due to common mode rejection.

Size Box Size Boxes allow you to minimize and maximize the window's size. You can also use the mouse to click on a window's size border to make it larger or smaller.

State Variable Variable used in the Command element to keep track of data not available in data channels.

Status Log Place where Snap-Master sends operating and error messages along with a time stamp. Most operating messages are sent to the queue only when the "Status Messages" checkbox is activated. In general, you should keep this option turned off. Error messages will always be sent to the Status Log, and are indicated by a ">" before the log time. To find out what error was recorded, highlight the log time and read the message on the right.

Streaming A/D conversions from a data acquisition board are continuously stored ("streaming to disk") at maximum transfer rates of computer.

Subroutine A named list of conditions and actions in the Command element equation table.

Terminal Count (T/C) Counter Timer event which occurs when the counter value reaches 0. The T/C is used to reload the initial counter value or to control other counters.

Thermocouple A temperature sensor created by joining two dissimilar metals. The junction produces a small voltage as a function of the temperature.

Throughput Rate The maximum repetitive rate at which a data conversion system can operate with a specified accuracy. It is determined by summing the various times required for each part of the system and then by taking the inverse of this time.

Token Used by the RS-232 instrument to represent information in a string sent by a piece of RS-232 equipment. Available token types include Literal Match, Place Holder, and Channel Data.

Toolbox The Toolbox is located on the left side of the workspace. All available element icons are placed in the instrument by dragging the icon from the Toolbox and dropping it in the Instrument window.

Transducer Converts an input (electrical or non-electrical) to an electrical output; examples are a strain gauge or thermocouple.

Transfer Rate The rate, measured in bytes/sec, at which data is moved from source to destination after software initialization and set up operations; the maximum rate at which the hardware can operate.

Trigger Pulse or signal that is used to start or stop a particular action. Triggers are frequently used to control data acquisition processes.

Unipolar A signal range that is always positive (for example, 0 to +10 V).

Waveform Analyzer Module Snap-Master module which performs time domain calculations. Data can be input from disk files, acquired using the Data Acquisition Module, or generated using the TIME function.

Window A window is a framed, rectangular area on a computer screen where you view data. Each window contains space to display the window title, controls for resizing the window, menus, and space for a program to run and display data. The selected, front-most window is referred to as the active window.

Workspace The Workspace is also known as the main Snap-Master window. This is where instrument windows are placed and where the Toolbox resides. When you exit Snap-Master, the current contents of the workspace are saved in a separate file.

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Appendix C. Aliasing

Aliasing is a phenomenon that occurs where high frequency components are shifted to a lower frequency, which produces an inaccurate representation of the data. This can occur in many different processes, including converting analog (continuous) data to digital (discrete) data, using Plot Techniques in to "subsample" the Display, etc. However, there are two techniques used to controlling the effects of aliasing: Nyquist's Sampling Theorem and anti-aliasing filters.

The phenomenon of aliasing can be seen in Western movies (as described by Enochson, Sound & Vibration, March 1987). A slowing stagecoach wheel will appear to rotate backward, stop, and then rotate forward at a decreasing speed as the stagecoach comes to a stop. According to Nyquist's Theorem, the maximum rotational rate we can observe is one-half of the 30 frames (or samples) per second frame rate, or 15 spokes per second. If the rate of the spokes exceeds this, then the film cannot properly reproduce the "continuous" image of the rotating spokes.

The result of this "aliasing" is the apparent backward rotation of the image. This occurs because the frame speed of the film is slower than the time taken for a spoke to rotate into the position occupied by the adjacent spoke when the previous frame was exposed. When the speed of the spoke's rotation matches the frame speed, the wheel appears to stand still. Then, as the wheel continues to slow, the frame speed becomes high enough to picture the spokes accurately, and the wheel appears to turn in the right direction at the right speed.

For example, when the wheel rotates at 16 spokes per second, the apparent rotation will be reversed at a rate of 14 spokes per second (from one cycle above 15 to one cycle below 15). This reversal phenomena is called "folding" in digital signal processing. If the spoke rate is 20 spokes per second, the observed phenomena would be backwards at 10 spokes per second (from five above 15 to five below 15).

Nyquist's Sampling Theorem

The most basic principle of sampling data to produce discrete data points is Nyquist's Sampling Theorem. Simply stated, the sampling frequency (or the number of times per second a data point is taken) must be at least two times the highest frequency present in the data. If there are less than two samples per cycle, then there is not sufficient data to accurately define the signal.

For example, if the data contains data up to a maximum frequency of 500 Hz, then you would need to sample the data at least 1000 times per second, or 1000 Hz. Note that the sampling rate is defined by the highest frequency present and not the highest frequency of interest. There is some probability that the data stream contains frequencies above the frequency of interest, and aliasing can occur from the effects of these higher frequencies. In practice, sampling rates as much as ten times the maximum frequency of interest are used. In many situations, the presence and magnitude of high frequency “noise” is not known. Conservative practice assumes that the signal contains data or noise to infinite frequency, but in some cases you may know the upper limit.

When the sampling rate exceeds the minimum defined by Nyquist's Theorem, the data is said to be "oversampled". Conversely, if the sampling rate is less than two times the frequency of interest, the data is "undersampled". Aliasing is most noticeable when undersampling occurs. In an ideal world, you would conservatively assume that a certain amount of high frequency noise is present, so you would use an infinite sampling rate. In the real world an infinite sampling rate is not possible so you must always undersample and risk a controlled amount of aliasing.

When you are acquiring data with the Data Acquisition Module, then the sampling rate of your input device defines the maximum frequency you can measure. Adjust the sampling rate to either maximize the frequency response of your data (higher sampling rate) or to minimize the number of data points read and possibly stored to disk (lower sampling rate). When generating signals with the Wave Generator element, make sure that the frame characteristics of the result element have a sufficient resultant sampling rate for the frequency of the signals you are generating.

Anti-Aliasing Filters

One way of minimizing aliasing with practical sampling rates is to use an anti-aliasing filter. Anti-aliasing filters are low-pass analog filters whose cutoff frequencies are set at or below one-half the sampling frequency. These are used for converting analog (continuous) data to digital (discrete) data using an A/D converter. The inputs to the filters are the signals from the physical sources, and the output of the filter is then sent to the data acquisition board.

However, the anti-aliasing filter may not be able to completely eliminate aliasing because analog filters cannot have a completely ideal vertical roll-off. There is a characteristic transition range, and data above their cut-off frequency is attenuated but not eliminated. The cutoff frequency of a filter is the frequency where the signal is attenuated by 3 dB (about 30%).

A good procedure for specifying the characteristics of an anti-aliasing filter is to consider (1) the desired highest frequency of unattenuated data, (2) the maximum tolerable contamination by aliased frequencies and (3) the phase distortion in the frequency range of interest, caused by the analog anti-aliasing filter.

- Depending on the shape of the filter characteristic curve in the transition region (where the filter is changing from a flat characteristic to its terminal slope), the cutoff frequency may have to be set much higher than the highest data frequency of interest. A very “sharp cutoff” filter will not require as much difference as a “soft transition” filter.

- Aliasing is effectively a “folding back” of data above half the sampling rate, and mixing it with data below that frequency (often called the Nyquist frequency). To have a maximum of 1% contamination of data by aliasing, the -40dB frequency of the filter must be less than half the sampling frequency. For a maximum of 0.1% contamination, the -60dB frequency of the filter must be less than half the sampling frequency.

- Analog filters always cause some phase (or time) shift between input and output. If different frequencies are shifted different amounts of time (“non-linear phase shift”), the time history of the signal is distorted. Some filter designs provide linear phase shift, or “constant group delay”. This means that all frequency components are shifted by an equal time, thus not distorting the data even though the whole signal is shifted in time. If the signals in different channels of a multi-channel system are phase shifted differently, you cannot compare event times accurately.

The specification for an anti-aliasing filter might be: “flat within +/-5% up to the maximum data frequency of interest, and at least 40dB attenuation at half the sampling frequency, and linear phase shift or constant group delay in the data frequency range”. This may require a higher sampling rate, or a sharp-cutoff anti-aliasing filter. Selection of sampling rate and anti-aliasing filter must be coordinated, and often require an economic tradeoff between a more-expensive high speed A/D converter and a more expensive sharper-cutoff filter. Also, in multi-channel systems, you may want to specify a maximum variation in phase shift (or time delay) between channels.

It is important to note that digital filtering does not help alias because the data as already been converted from the analog to the digital domain, aliasing and all. The digital filter cannot separate a legitimate component from an aliased one, because it has no idea what the original signal was. As a result, anti-aliasing filters must be analog filters.

Appendix D. DDE Commands and Parameters

D.1. System 2
D.2. Workspace 3
D.3. Instrument 3
D.4. A/D Demo 4
D.5. Display 4
D.6. Disk In 10
D.7. Disk Out 12
D.8. DDE Out 12
D.9. Sensor 13
D.10. A/D Device, Digital In, Counter Timer In 14
D.11. D/A Device 16
D.12. Digital Out 16
D.13. Analysis 17
D.14. Command 17
D.15. FFT 18
D.16. Relay 18
D.17. Histogram 19
D.18. MultiFrame 19

DDE Support

This appendix lists the DDE commands and parameters available in Snap-Master. This information is intended for users who are knowledgeable about DDE and who want to use these capabilities in their own macros and programs. The service name for these commands is "Snap-Master", with the items listed by topic.

The standard technical support for Snap-Master DOES NOT include applications programming of Snap-Master via DDE. The Snap-Master Front Panel Library provides example source code for developing custom programs, and it carries a separate support policy. Please contact HEM Data for more information on this and other programming tool kits for Snap-Master.

Execute

DDE Commands are sent by the client application to the server using the DDE Execute method. The Service Name and Topic strings are separated by a vertical bar (ANSI character 124, or SHIFT+\ on an extended keyboard), and the Topic and Item strings are separated by an exclamation point. The format of a DDE Command is as follows:

Service Name:	Snap-Master
Topic Name:	Instrument Name
Item Name:	ElementLetter:ExecuteCommand,Data

If any data accompanies the command, a comma and the data are appended to the Item. In the tables listing the available commands, the data column specifies the data that must be sent with the command. If there is no data specified, then the comma and data are not sent.

The following examples illustrate a DDE Execute without data and a DDE Execute with data. Assume that the instrument name is TEST.INS and the Sensor is element letter A.

Without: "Snap-Master"|"TEST.INS"!"A:FileNew"

With: "Snap-Master"|"TEST.INS"!"A:FileOpen,C:\SM\NEXT.ASN"

Request

For a DDE Request, the client application asks the server what the current value of the DDE Item is. This text is always returned as a string, and the following tables list what type of information is returned by Snap-Master. The Service Name and Topic strings are separated by a vertical bar (ANSI character 124, or SHIFT+\ on an extended keyboard), and the Topic and Item strings are separated by an exclamation point. The format of a DDE Request is as follows:

Service Name:	Snap-Master
Topic Name:	Instrument Name
Item Name:	ElementLetter:RequestItem

The following examples illustrate three DDE Requests to the A/D Demo element: one that returns a number, one that returns a string, and one that returns a predefined answer. Assume that the instrument name is TEST.INS and the A/D Demo is element letter A.

Number: "Snap-Master"|"TEST.INS"!"A:SampleRate"
Returns: "100"

String: "Snap-Master"|"TEST.INS"!"A:Units"
Returns: "Secs"

Answer: "Snap-Master"|"TEST.INS"!"A:Continuous"
Returns: "YES"

Poke

For a DDE Poke, the client application tells the server the new value of the DDE Item. This text is always sent as a string, and the following tables list what type of information Snap-Master is expecting. The Service Name and Topic strings are separated by a vertical bar (ANSI character 124, or SHIFT+\ on an extended keyboard), and the Topic and Item strings are separated by an exclamation point. The format of a DDE Poke is as follows:

Service Name:	Snap-Master
Topic Name:	Instrument Name
Item Name:	ElementLetter:PokeItem,NewValue

The following examples illustrates three DDE Pokes to the A/D Demo element. Assume that the instrument name is TEST.INS and the A/D Demo is element letter A.

Number: "Snap-Master"|"TEST.INS"!"A:SampleRate,100"

String: "Snap-Master"|"TEST.INS"!"A:Units,Secs"

Answer: "Snap-Master"|"TEST.INS"!"A:Continuous,YES"

D.1. System

Topic	Item	Exec	Req	Poke	Format	Comments
System	Topics		✓		string	Main, open instrument list
System	SysItems		✓		string	DDE items for System topic
System	Status		✓		string	"Ready"
System	Formats		✓		string	supported DDE data formats

Notes: For commands to the Snap-Master system, the Topic is "System" and the Item is the request. For example, "Snap-Master"|"System"|"Topics".

D.2. Workspace

Topic	Item	Exec	Req	Poke	Format	Comments
Main	FileNew	✓				
Main	FileOpen,*filename*	✓				full path and file name
Main	FileSave	✓				
Main	FileSaveAs,*filename*	✓				full path and file name
Main	FileClose,*filename*	✓				closes *filename* instrument if *filename* omitted, closes active instrument window
Main	FileExit	✓				
Main	OptionsShowLog	✓				displays the Status Log
Main	OptionsHideLog	✓				hides the Status Log
Main	StatusLogVisible		✓		string	"Yes", "No"
Main	OptionsAutoArrange,*status*		✓	✓	string	"On", "Off"
Main	OptionsToolbox,*status*		✓	✓	string	"On", "Off"
Main	WindowCascade	✓				
Main	WindowTile	✓				
Main	WindowArrange	✓				
Main	HelpTutorial	✓				
Main	HelpAbout	✓				
Main	Hide	✓				hides workspace window
Main	Show	✓				shows workspace window
Main	DisplayConfirmDelete		✓	✓	string	"Yes", "No"
Main	ConfirmSaveOnClose		✓	✓	string	"Yes", "No"; determines if user is asked to save instrument before closing the window
Main	Path		✓		string	file path of SM.EXE
Main	DefuserPath		✓		string	directory path of \DEFUSER
Main	SysdataPath		✓		string	directory path of \SYSDATA
Main	Version,*dllname*		✓		string	version string from About box of specified Snap-Master DLL file.

Notes: Replace *filename* with the full path and file name for the instrument.

Replace *status* with either On or Off.

D.3. Instrument

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	@:Start	✓				
instrument	@:Stop	✓				
instrument	@:ElementLetters		✓		string	element letters used in instrument
instrument	@:ElementNames		✓		string	element names used in instrument
instrument	@:ElementName,*ElementLetter*		✓		string	element name for element letter
instrument	@:Running		✓		string	"Yes", "No"

Notes: Replace *ElementLetter* with the element letter you want the name for. For example to retrieve the element name for element letter A, use "Snap-Master|TEST.INS!@:ElementName,A".

D.4. A/D Demo

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	SampleRate		✓	✓	single	
instrument	Units		✓	✓	string	
instrument	Label		✓	✓	string	
instrument	Duration		✓	✓	single	
instrument	NumberOfPoints		✓	✓	long int	
instrument	Continuous		✓	✓	string	"Yes", "No"
instrument	StopAfter		✓	✓	long int	
instrument	FirstChannel		✓		integer	lowest available channel number
instrument	LastChannel		✓		integer	highest available channel number
instrument	SelectedChannels		✓		string	list of active channels
instrument	NumSelectedChannels		✓		integer	
instrument	ClockType		✓		string	"Internal", "External"
instrument	MinChannel		✓		integer	lowest active channel number
instrument	MaxChannel		✓		integer	highest active channel number
instrument	*num*.On		✓		string	"Yes" if channel num is active, use just number portion

D.5. Display

Menu And Window Commands

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	CommandBar		✓	✓	string	“Yes”, “No”
instrument	ScrollBar		✓	✓	string	“Yes”, “No”
instrument	StatusBar		✓	✓	string	“Yes”, “No”
instrument	AutoRetrace		✓	✓	string	“Yes”, “No”
instrument	RetraceMode		✓	✓	string	“Buffer”, “Full”
instrument	FileNew	✓				
instrument	FileOpen,*filename*	✓				full path and file name
instrument	FileSave	✓				
instrument	FileSaveAs,*filename*	✓				full path and file name
instrument	FileClose	✓				
instrument	PrintDisplay	✓				
instrument	PrintDesktop	✓				Screen Copy mode only
instrument	RetraceNow	✓				
instrument	ShowDisplay	✓				
instrument	MaximizeDisplay	✓				
instrument	MinimizeDisplay	✓				
instrument	ShowCursorData	✓				
instrument	CloseCursorData	✓				
instrument	MaximizeCursorData	✓				
instrument	MinimizeCursorData	✓				
instrument	*Plot#*.AutoRescale	✓				
instrument	Page			✓	integer	activates selected page
instrument	AutoLayout			✓		

Default Settings

Topic	Item	Exec	Req	Poke	Format	Comments
Main	DisplayConfirmDelete		✓	✓	string	"Yes", "No" ; note Topic is Main
instrument	DefaultAutoLayoutMode		✓	✓	integer	0: Off 1: One Channel Per Plot 2: Overplot Same Element Letter 3: Overplot Same Channel Number 4: Overplot With Same Units
instrument	AutoLayoutOverplotMultipleYAxes		✓	✓	string	“Yes”, “No”
instrument	AutoLayoutOverplotWarnUnits		✓	✓	string	“Yes”, “No”
instrument	AutoLayoutOverplotNumChs		✓	✓	integer	
instrument	AutoLayoutOverplotWarnDelete		✓	✓	string	“Yes”, “No”
instrument	DefaultCursorsSelectAllChs		✓	✓	string	“Yes”, “No”
instrument	DefaultCommandBar		✓	✓	string	“Yes”, “No”
instrument	DefaultScrollBar		✓	✓	string	“Yes”, “No”
instrument	DefaultStatusBar		✓	✓	string	“Yes”, “No”
instrument	DefaultAutoRetrace		✓	✓	string	“Yes”, “No”
instrument	DefaultRetraceMode		✓	✓	string	“Buffer”, “Full”
instrument	DefaultPlotTechnique		✓	✓	string	“All”, “Automatic”

Printing

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	PrintMethod		✓	✓	integer	1: ScreenCopy - Display Page 2: ScreenCopy - Desktop 3: High Res - Black & White 4: High Res - Color
instrument	PrintHiResSepLines		✓	✓	string	“Yes”, “No”
instrument	PrintHiResWindowTitle		✓	✓	string	“Yes”, “No”
instrument	PrintHiResDateTime		✓	✓	string	“Yes”, “No”
instrument	PrintLeftMargin		✓	✓	single	
instrument	PrintRightMargin		✓	✓	single	
instrument	PrintTopMargin		✓	✓	single	
instrument	PrintBottomMargin		✓	✓	single	

Default Print Settings

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	DefaultPrintMethod		✓	✓	integer	1: ScreenCopy - Display Page 2: ScreenCopy - Desktop 3: High Res - Black & White 4: High Res - Color
instrument	DefaultPrintHiResSepLines		✓	✓	string	“Yes”, “No”
instrument	DefaultPrintHiResWindowTitle		✓	✓	string	“Yes”, “No”
instrument	DefaultPrintHiResDateTime		✓	✓	string	“Yes”, “No”
instrument	DefaultPrintLeftMargin		✓	✓	single	
instrument	DefaultPrintRightMargin		✓	✓	single	
instrument	DefaultPrintTopMargin		✓	✓	single	
instrument	DefaultPrintBottomMargin		✓	✓	single	

Layout - Page Settings

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	*Page#*.PageDefaultTitle		✓	✓	string	"Yes", "No"; replace *Page#* with Page and number in # column (i.e. Page1)
instrument	*Page#*.Title		✓	✓	string	
instrument	*Page#*.AutoRows		✓	✓	string	"Yes", "No"
instrument	*Page#*.Rows		✓	✓	integer	
instrument	*Page#*.AutoCols		✓	✓	string	"Yes", "No"
instrument	*Page#*.Cols		✓	✓	integer	

Layout - Display Layout

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	NumPlots		✓		integer	number of plots defines in the layout table
instrument	*Plot#*.Page		✓		integer	replace *Plot#* with Plot and number in # column (i.e. Plot5); "None" or 1-8
instrument	*Plot#*.PlotType		✓		string	
instrument	*Plot#*.ChList		✓		string	CSV list of channels in plot

Plot Settings

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	*Plot#*.Title		✓	✓	string	
instrument	*Plot#*.TitleState		✓	✓	integer	0: Show No Title 1: Show Default Title 2: Show User Supplied Title
instrument	*Plot#*.SubTitle		✓	✓	string	
instrument	*Plot#*.ShowSubTitle		✓	✓	string	"Yes", "No"
instrument	*Plot#*.TechniqueMode		✓	✓	integer	contents of Plotting Technique Mode combo
instrument	*Plot#*.TechniquePoints		✓	✓	integer	Waveform plots only
instrument	*Plot#*.TechniqueDraw		✓	✓	string	contents of Plotting Technique Draw combo; Waveform plots only
instrument	*Plot#*.TechniqueRate		✓	✓	single	Single Value plots only
instrument	*Plot#*.ShowLegend		✓	✓	string	"None", "Inside Grid", "Right Margin"
instrument	*Plot#*.ShowFrameNumber		✓	✓	string	"Yes", "No"
instrument	*Plot#*.IndicatorShape		✓	✓	string	contents of Shape combo; Indicator plots only
instrument	*Plot#*.DefaultLocation		✓	✓	string	"Yes", "No"; Single Value plots only
instrument	*Plot#*.LockLocation		✓	✓	string	"Yes", "No"; Single Value plots only
instrument	*Plot#*.AutoRows		✓	✓	string	"Yes", "No"; Single Value plots only
instrument	*Plot#*.Rows		✓	✓	integer	Single Value plots only
instrument	*Plot#*.AutoCols		✓	✓	string	"Yes", "No"; Single Value plots only
instrument	*Plot#*.Cols		✓	✓	integer	Single Value plots only

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	*Plot#*.ShowChannel		✓	✓	string	"Label", "Number"; Single Value plots only
instrument	*Plot#*.Scaled		✓	✓	string	"Scaled", "Unscaled"; Single Value plots only
instrument	*Plot#*.ChannelVisible		✓	✓	string	"Yes", "No"; Single Value plots only
instrument	*Plot#*.UnitsVisible		✓	✓	string	"Yes", "No"; Single Value plots only
instrument	*Plot#.Item*.FontName		✓	✓	string	replace *Item* with entry from Fonts Item list; pass valid font name
instrument	*Plot#.Item*.FontStyle		✓	✓	string	"Regular", "Italic", "Bold", "Bold Italic"
instrument	*Plot#.Item*.FontSize		✓	✓	single	valid font metric
instrument	*Plot#.Item*.Color		✓	✓	string	RGB values separated by commas

X-Axis Settings (Waveform Plots)

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	*Plot#*.XAxisLabel		✓	✓	string	
instrument	*Plot#*.XAxisDefaultLabel		✓	✓	string	"Yes", "No"
instrument	*Plot#*.XAxisShowLabel		✓	✓	string	"Yes", "No"
instrument	*Plot#*.XAxisType		✓	✓	string	Y-T: "Linear", "Logarithmic"
instrument	*Plot#*.XAxisAction		✓	✓	string	"Stationary", "Moving", "Sweep"
instrument	*Plot#*.XAxisAutoClear		✓	✓	string	"Yes", "No"
instrument	*Plot#*.XAxisChannel		✓	✓ (Y-X, Scatter)	string	Y-X, Scatter: channel number Y-T, Strip-Chart: "Time" (Request only) Mag-F, Phase-F: "Frequency" (Request only)
instrument	*Plot#*.XAxisLocation		✓	✓	string	contents of Location combo
instrument	*Plot#*.XAxisDefaultScale		✓	✓	string	"Yes", "No"
instrument	*Plot#*.XAxisMin		✓	✓	string	use string for time of day support
instrument	*Plot#*.XAxisMax		✓	✓	string	use string for time of day support
instrument	*Plot#*.XAxisFormat		✓	✓	string	contents of Format combo
instrument	*Plot#*.XAxisSignificantDigits		✓	✓	string	fill out edit controls as passed for time of day support
instrument	*Plot#*.XAxisMajorDivisions		✓	✓	integer	
instrument	*Plot#*.XAxisShowMajorDivisions		✓	✓	string	"None", "Vertical Grid", "Tick Mark"
instrument	*Plot#*.XAxisShowAxisValues		✓	✓	string	"None", "Minimum and Maximum", "All Major Divisions"
instrument	*Plot#*.XAxisMinorDivisions		✓	✓	integer	
instrument	*Plot#*.XAxisShowMinorDivisions		✓	✓	string	"None", "Tick Mark"

Y-Axis Settings (Waveform Plots)

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	*Plot#*.YAxisDefaultLabel		✓	✓	string	"Yes", "No"
instrument	*Plot#*.YAxisType		✓	✓	string	Y-T: "Linear", "Logarithmic", "db (10x)", "db (20x)"
instrument	*Plot#*.YAxisMultipleYAxes		✓	✓	string	"Yes", "No"
instrument	*Plot#*.YAxisLocation		✓	✓	string	contents of Location combo
instrument	*Plot#*.YAxisDefaultScale		✓	✓	string	"Yes", "No"
instrument	*Plot#*.YAxisFormat		✓	✓	string	contents of Format combo
instrument	*Plot#*.YAxisShowMajorDivisions		✓	✓	string	"None", "Vertical Grid", "Tick Mark"
instrument	*Plot#*.YAxis*Axis#*.ShowAxisValues		✓	✓	string	"None", "Minimum and Maximum", "All Major Divisions"
instrument	*Plot#*.YAxis*Axis#*.RotateValues		✓	✓	string	"Yes", "No"
instrument	*Plot#*.YAxisShowMinorDivisions		✓	✓	string	"None", "Tick Mark"
instrument	*Plot#*.YAxis*Axis#*.Label		✓	✓	string	replace *Axis#* with the axis number being edited (1-10)
instrument	*Plot#*.YAxis*Axis#*.ShowLabel		✓	✓	string	"Yes", "No"
instrument	*Plot#*.YAxis*Axis#*.Min		✓	✓	single	
instrument	*Plot#*.YAxis*Axis#*.Max		✓	✓	single	
instrument	*Plot#*.YAxis*Axis#*.SignificantDigits		✓	✓	string	fill out edit controls as passed
instrument	*Plot#*.YAxis*Axis#*.MajorDivisions		✓	✓	integer	
instrument	*Plot#*.YAxis*Axis#*.MinorDivisions		✓	✓	string	

Channel Settings (Waveform Plots)

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	*Plot#.Ch#*.Channel		✓	✓	string	replace Ch# with Ch1, Ch2, etc.; valid channel
instrument	*Plot#.Ch#*.ChannelColor		✓	✓	string	RGB values separated by commas
instrument	*Plot#.Ch#*.LineStyle		✓	✓	integer	item selected in combo list
instrument	*Plot#.Ch#*.Thickness		✓	✓	integer	
instrument	*Plot#.Ch#*.YAxisNumber		✓	✓	integer	
instrument	*Plot#.Ch#*.ShowAs		✓	✓	string	"Label:, "Number"

Channel Settings (Single Value Plots)

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	*Plot#.Ch#*.NumColors		✓	✓	integer	1, 2, or 3; valid for DigitalMeter, Indicator, DialMeter plots
instrument	*Plot#.Ch#*.ColorOneMin		✓	✓	single	
instrument	*Plot#.Ch#*.ColorOneMax		✓	✓	single	
instrument	*Plot#.Ch#*.ColorOneValueColor		✓	✓	string	RGB values separated by commas; Dial Meter set Needle color
instrument	*Plot#.Ch#*.ColorOneBkgndColor		✓	✓	string	RGB values separated by commas; Dial Meter set Dial color
instrument	*Plot#.Ch#*.ColorTwoMin		✓	✓	single	
instrument	*Plot#.Ch#*.ColorTwoMax		✓	✓	single	
instrument	*Plot#.Ch#*.ColorTwoValueColor		✓	✓	string	RGB values separated by commas; Dial Meter set Needle color
instrument	*Plot#.Ch#*.ColorTwoBkgndColor		✓	✓	string	RGB values separated by commas; Dial Meter set Dial color

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	*Plot#.Ch#.*ColorThreeMin		✓	✓	single	
instrument	*Plot#.Ch#.*ColorThreeMax		✓	✓	single	
instrument	*Plot#.Ch#.*ColorThreeValueColor		✓	✓	string	RGB values separated by commas; Dial Meter set Needle color
instrument	*Plot#.Ch#.*ColorThreeBkgndColor		✓	✓	string	RGB values separated by commas; Dial Meter set Dial color
instrument	*Plot#.Ch#.*DigitalMeterFormat		✓	✓	string	"Decimal", "Scientific", "Engineering"
instrument	*Plot#.Ch#.*DigitalMeterDigits		✓	✓	string	fill out edit controls as passed
instrument	*Plot#.Ch#.*BarMeterDirection		✓	✓	string	"Vertical", "Horizontal"
instrument	*Plot#.Ch#.*BarMeterPictureStyle		✓	✓	string	any pre-defined style from the Style combo except "User Defined"
instrument	*Plot#.Ch#.*DialMeterStartAngle		✓	✓	single	value between 0 and 360
instrument	*Plot#.Ch#.*DialMeterEndAngle		✓	✓	single	value between 0 and 360
instrument	*Plot#.Ch#.*DialMeterStartValue		✓	✓	single	set the min value
instrument	*Plot#.Ch#.*DialMeterEnd Value		✓	✓	single	set the max value
instrument	*Plot#.Ch#.*DialMeterDivisions		✓	✓	integer	
instrument	*Plot#.Ch#.*DialMeterNeedleWidth		✓	✓	integer	

Plot Settings (Histogram Plots)

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	*Plot#.Ch#.*HistogramAppearance		✓	✓	string	"Lines", "Bars"
instrument	*Plot#.Ch#.*HistogramFilled		✓	✓	string	"Yes", "No"
instrument	*Plot#.Ch#.*HistogramBarWidth		✓	✓	single	percentage

Cursors And Markers

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	*Plot#.*NewCursor	✓				
instrument	*Plot#.*NewMarker	✓				
instrument	*Cursor#.*VeriticalCrossHair		✓	✓	string	"Yes", "No"
instrument	*Cursor#.*HorizontalCrossHair		✓	✓	string	"Yes", "No"
instrument	*Cursor#.*SkipRate		✓	✓	integer	also for markers
instrument	*Marker#.*Label		✓	✓	string	
instrument	*Marker#.*Background		✓	✓	string	contents of Background combo
instrument	*Marker#.*FontName		✓	✓	string	replace *Item* with entry from Fonts Item list; pass valid font name
instrument	*Marker#.*FontStyle		✓	✓	string	"Regular", "Italic", "Bold", "Bold Italic"
instrument	*Marker#.*FontSize		✓	✓	string	valid font metric
instrument	*Marker#.*HorizontalPosition		✓	✓	string	"Left", "Center", "Right"
instrument	*Marker#.*VerticalPosition		✓	✓	string	"Top", "Center", "Bottom"
instrument	*Marker#.*Fill		✓	✓	string	contents of Fill combo
instrument	*Marker#.*Color		✓	✓	string	RGB values separated by commas
instrument	*Marker#.*Shape		✓	✓	string	"Rectangle". "Ellipse"
instrument	*Marker#.*Height		✓	✓	integer	
instrument	*Marker#.*Width		✓	✓	integer	

Cursor Table

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	*Cursor#*.Ch		✓		string	
instrument	*Cursor#*.Pt#		✓	✓	long int	
instrument	*Cursor#*.XValue		✓	✓	single	
instrument	*Cursor#*.XUnits		✓		string	
instrument	*Cursor#*.YValue		✓		single	
instrument	*Cursor#*.YUnits		✓		string	
instrument	*Cursor#*.Type		✓		string	"Abs", "Rel", "Marker"
instrument	*Cursor#*.Slope		✓		single	valid only for Rel cursor
instrument	*Cursor#*.Pg		✓		integer	
instrument	*Cursor#*.Title		✓		string	
instrument	*Cursor#*.Show		✓	✓	string	"Yes", "No"

D.6. Disk In

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	FileName		✓	✓	string	full path and file name
instrument	FileComments		✓		string	
instrument	AllFrames		✓	✓	string	"Yes", "No"
instrument	StartAtFrame		✓	✓	long int	
instrument	StopAtFrame		✓	✓	long int	
instrument	Continuous		✓	✓	string	"Yes", "No"
instrument	PauseAfter		✓	✓	long int	
instrument	Paced		✓	✓	string	"Yes", "No"
instrument	PlaybackSpeed		✓	✓	integer	speed multiple between -10 (slowest) and 10 (fastest), with 0 equaling normal speed

ASCII Import

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	Rate		✓	✓	single	
instrument	Duration		✓	✓	single	
instrument	Points		✓	✓	long int	
instrument	MinY		✓	✓	single	
instrument	MaxY		✓	✓	single	
instrument	FrameLengthType		✓	✓	string	“Duration”, “Points”
instrument	LinesToSkip		✓	✓	integer	
instrument	UseLabels		✓	✓	string	"Yes", "No"
instrument	AutoDetectPts		✓	✓	string	"Yes", "No"

File Info

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	BufferLetters		✓		string	CSV list of element letters used by DAT file
instrument	*Letter*.Date		✓		string	date file was created
instrument	*Letter*.Time		✓		string	time file was created
instrument	*Letter*.ActFreq		✓		single	sample rate of element letter
instrument	*Letter*.ActSweep		✓		single	frame duration in Clock Units
instrument	*Letter*.NumChans		✓		integer	number of channels in file
instrument	*Letter*.Channels		✓		string	CSV list of channels (element letter and channel number)
instrument	*Letter*.NumPoints		✓		long int	frame duration in Number of Points
instrument	*Letter*.ClockUnits		✓		string	X-axis units
instrument	*Letter*.FileType		✓		sting	"Exponential", "Standard Binary", or "Fast Binary"
instrument	*Letter*.Interleave		✓		integer	same as number of channels in file
instrument	*Letter*.FFTBlockSize		✓		integer	interleave of FFT data
instrument	*Letter*.PreTriggerPts		✓		long int	number of pre-trigger points used when acquiring data
instrument	*Letter*.DataInfo		✓		string	
instrument	*Letter.ChOffset*.ConversionPoly		✓		string	factor and offset in mX+b format
instrument	*Letter.ChOffset*.ChanUnits		✓		string	
instrument	*Letter.ChOffset*.DefaultLabel		✓		integer	1 or 0
instrument	*Letter.ChOffset*.ChanLabel		✓		string	channel label
instrument	*Letter.ChOffset*.ChanType		✓		string	"yt" (time), "yfp" (frequency)
instrument	*Letter.ChOffset*.ChanMinY		✓		single	default channel minimum
instrument	*Letter.ChOffset*.ChanMaxY		✓		single	default channel maximum

For all file info items except BufferLetters, *Letter* must be replaced by the element letter of the buffer (.SM?) you are requesting.

For channel specific information, *ChOffset* must be replaced by the 0-based sequential location of the channel from the Channels string. For example, if the Channels item returns "A0,A5,A10,A15" and you are interested in the ConversionPoly for channel A10, the Item would be A.2.ConversionPoly (channel A10 is the third channel in the list, which is item 2 in a 0-based sequence).

If *ChOffset* is replaced by the value -1, the complete header string is returned for all channels.

D.7. Disk Out

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	NamingStyle		✓	✓	string	"DateTime", "SeedName", "Ordinary"
instrument	FileName		✓	✓	string	full path and file name
instrument	FileSaveAllChannels		✓	✓	string	"Yes", "No"
instrument	FileSaveChannel		✓	✓	string	space delimited list of valid channels (for example, "A0 A1 A2 R0 S0").
instrument	FileComments		✓	✓	string	
instrument	FileFormat		✓	✓	string	"Exponential", "Binary", "FBDF", "ASCII Plotter", "Binary Plotter", "CSV"
instrument	StartAtFrame		✓	✓	long int	
instrument	StopAtFrame		✓	✓	long int	
instrument	Continuous		✓	✓	string	"Yes", "No"
instrument	PauseAfter		✓	✓	long int	
instrument	Paced		✓	✓	string	"Yes", "No"
instrument	PlaybackSpeed		✓	✓	integer	speed multiple between -10 (slowest) and 10 (fastest), with 0 equaling normal speed

D.8. DDE Out

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	*DDEOut*:*ChNum*.data		✓		string	pointwise data values
instrument	*DDEOut*:*ChNum*.xLabel		✓		string	X-axis label
instrument	*DDEOut*:*ChNum*.xUnits		✓		string	X-axis units
instrument	*DDEOut*:*ChNum*.points		✓		string	Frame duration (in points)
instrument	*DDEOut*:*ChNum*.rate		✓		string	Sample rate
instrument	*DDEOut*:*ChNum*.frameNumber		✓		string	Current frame number
instrument	*DDEOut*:*ChNum*.yLabel		✓		string	Y-axis label
instrument	*DDEOut*:*ChNum*.yUnits		✓		string	Y-axis units
instrument	*DDEOut*:*ChNum*.factor		✓		string	Factor
instrument	*DDEOut*:*ChNum*.offset		✓		string	Offset
instrument	*DDEOut*:*ChNum*.yMin		✓		string	Default Y-axis minimum
instrument	*DDEOut*:*ChNum*.yMax		✓		string	Default Y-axis maximum

Notes: Replace *DDEOut* with the element letter of the DDE Out element, and replace *ChNum* with the element letter and channel number of the channel whose information you want. For example, to get the frame number of channel A0 through the DDE Out element designated as element Z, the item is "Z:A0.frameNumber".

A hot or warm link can be designated to these DDE Out items.

When the Block Mode setting is greater than 1, all values sent by the data item are separated by a Carriage Return, Line Feed.

For more information on the DDE Out element, refer to Chapter 6.

D.9. Sensor

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	FileNew	✓				
instrument	FileOpen,*filename*	✓				full path and file name
instrument	FileSave	✓				
instrument	FileSaveAs,*filename*	✓				full path and file name
instrument	FileClose	✓				
instrument	Insert,*SensorID*	✓				unique sensor ID
instrument	Delete,*SensorID*	✓				existing sensor ID
instrument	View		✓	✓	string	"Assigned", "All"
instrument	NumIDs		✓		integer	total number of IDs in database
instrument	*RowNum*.SensorID		✓		string	returns specific ID when view All
instrument	*SensorID*.Channel		✓	✓	string	
instrument	*SensorID*.Label		✓	✓	string	
instrument	*SensorID*.ModelNumber		✓	✓	string	
instrument	*SensorID*.Kind		✓	✓	string	
instrument	*SensorID*.Type		✓	✓	string	
instrument	*SensorID*.Manufacturer		✓	✓	string	
instrument	*SensorID*.SerialNumber		✓	✓	string	
instrument	*SensorID*.Factor		✓	✓	single	
instrument	*SensorID*.Offset		✓	✓	single	
instrument	*SensorID*.InMin		✓	✓	single	
instrument	*SensorID*.InMax		✓	✓	single	
instrument	*SensorID*.InUnits		✓	✓	string	
instrument	*SensorID*.OutMin		✓	✓	single	
instrument	*SensorID*.OutMax		✓	✓	single	
instrument	*SensorID*.OutUnits		✓	✓	string	
instrument	*SensorID*.FreqMax		✓	✓	single	
instrument	*SensorID*.CalDate		✓	✓	string	date (MM/DD/YY)
instrument	*SensorID*.Interval		✓	✓	long int	
instrument	*SensorID*.NextCalDate		✓		string	date (MM/DD/YY)
instrument	*SensorID*.NumHistory		✓		integer	number of history entries for the sensor ID
instrument	*SensorID*.CalHistory.*RowNum*		✓		string	date (MM/DD/YY) of specified history
instrument	*SensorID*.ScalingInfo.*RowNum*		✓		string	comma separated string with Factor, Offset, InMin, InMax, InUnits, OutMin, OutMax, OutUnits
instrument	DependentRange		✓	✓	string	"Factor/Offset", "Input", "Output"

Notes: Replace *SensorID* with a valid sensor ID from the database. For example, to get the input units of sensor F-59 to psi, the Request item is "F-59.InUnits ".

To get a list of all IDs in the Sensor database, use NumIDs to read the number of IDs then *RowNum*.SensorID to read each ID.

To get a complete calibration history of a particular sensor, use *SensorID*.NumHistory to read the number of history entries then *SensorID*.CalHistory.*RowNum* to read the date and *SensorID*.ScalingInfo.*RowNum* to read the scaling data for each calibration entry.

D.10. A/D Device, Digital In, Counter Timer In

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	SampleRate		✓	✓	single	
instrument	Units		✓	✓	string	
instrument	Label		✓	✓	string	
instrument	Duration		✓	✓	single	
instrument	NumberOfPoints		✓	✓	long int	
instrument	Continuous		✓	✓	string	"Yes", "No"
instrument	StopAfter		✓	✓	long int	
instrument	FirstChannel		✓		integer	lowest available channel number
instrument	LastChannel		✓		integer	highest available channel number
instrument	SelectedChannels		✓		string	space delimited list of active channels (for example, "0 1 2 4")
instrument	NumSelectedChannels		✓		integer	
instrument	ClockType		✓		string	"Internal", "External"
instrument	MinChannel		✓		integer	lowest active channel number
instrument	MaxChannel		✓		integer	highest active channel number
instrument	HardwareType		✓		string	
instrument	OpenConfig		✓		none	opens Configuration dialog
instrument	DeviceNum		✓	✓	integer	1 to 8
instrument	ProgRangeType		✓		string	"One", "Per Channel", or "None"
instrument	JumperRangeType		✓		string	"One", "Per Channel", or "None"
instrument	*ChNum*.ListProgRanges		✓		string	Comma separated list of all available programmable ranges for the channel. Use for software programmable gain hardware.
instrument	*ChNum*.ListJumperRanges		✓		string	Comma separated list of all available programmable ranges for the channel. Use for jumper programmed gain hardware.
instrument	*ChNum*.ProgRange		✓	✓	string	valid range string
instrument	*ChNum*.On		✓		string	"Yes" if channel is active, use just number portion
instrument	*ChNum*.Factor		✓	✓	single	
instrument	*ChNum*.Offset		✓	✓	single	
instrument	*ChNum*.YLabel		✓	✓	string	
instrument	*ChNum*.YUnits		✓	✓	string	

Counter Timer Settings

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	*ChipNum.*Prescaler		✓	✓	string	"Binary", "BCD"
instrument	*ChipNum.*FoutEnabled		✓	✓	string	"Yes", "No"
instrument	*ChipNum.*FoutSource		✓	✓	string	"T/C n-1", "Src1", "Src2", "Src3", "Src4", "Src5", "Gate1", "Gate2", "Gate3", "Gate4", "Gate5", "F1", "F2", "F3", "F4", "F5"
instrument	*ChipNum.FoutDivider*		✓	✓	integer	1 to 16
instrument	*ChipNum.CounterNum.*Function		✓	✓	string	"Internal Pacer", "Mode", "Custom", "Pacer", "Frequency", "One Shot", "Pulse Count", "Pulse Width", "Rate Gen", "Rate Gen Gated"
instrument	*ChipNum.CounterNum.*Source		✓	✓	string	"T/C n-1", "Src1", "Src2", "Src3", "Src4", "Src5", "Gate1", "Gate2", "Gate3", "Gate4", "Gate5", "F1", "F2", "F3", "F4", "F5"
instrument	*ChipNum.CounterNum.*CountOn		✓	✓	string	"Rising Edge", "Falling Edge"
instrument	*ChipNum.CounterNum.*Gate		✓	✓	string	"None", "Hi T/C n-1", "Hi Level n+1", "Hi Level n-1", "Hi Level n", "Lo Level n", "Hi Edge n", "Lo Edge n"
instrument	*ChipNum.CounterNum.*Output		✓	✓	string	"Always Hi", "Always Lo", "Hi T/C Pulse", "Lo T/C Pulse", "T/C Toggle"
instrument	*ChipNum.CounterNum.*LoadRegister		✓	✓	long int	0 to 65535
instrument	*ChipNum.CounterNum.*HoldRegister		✓	✓	long int	0 to 65535
instrument	*ChipNum.CounterNum.*Count		✓	✓	string	"Up", "Down"
instrument	*ChipNum.CounterNum.*TCReload		✓	✓	string	"Load Only", "Load Hold"
instrument	*ChipNum.CounterNum.*Cycle		✓	✓	string	"Once", "Repeat"
instrument	*ChipNum.CounterNum.*Format		✓	✓	string	"Binary", "BCD"
instrument	*ChipNum.CounterNum.*SpecialGate		✓	✓	string	"Enabled", "Disabled"

Triggers

The following Trigger DDE commands are currently implemented only with HDI supported hardware.

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	TriggerMode		✓	✓	string	"Standard", "Hardware Dependent"
instrument	TriggerType		✓	✓	string	“Free Running”, “Analog”, “Digital”
instrument	TriggerChannel		✓	✓	string	Analog: element letter and channel number Digital: “Bit ” and bit number
instrument	TriggerCondition		✓	✓	string	Analog: “Above”, “Below”, “Inside”, “Outside”, “Positive Slope”, “Negative Slope” Digital: “Equal”, “Not Equal”, “Rising Edge”, “Falling Edge”
instrument	TriggerUnits		✓	✓	string	“Sensor”, “A/D”
instrument	TriggerLevels		✓	✓	string	“1”, “2”
instrument	TriggerLevel1		✓	✓		Analog: single Digital: string of binary bit mask
instrument	TriggerLevel2		✓	✓		Analog: single Digital: string of binary bit mask
instrument	TriggerExclusive		✓	✓	string	"Yes", "No"
instrument	TriggerPreTrigger		✓	✓	string	"Yes", "No"
instrument	TriggerPreTriggerAs		✓	✓	string	“Points”, “Seconds”, “% Frame Length”
instrument	TriggerPreTriggerValue		✓	✓	single	

Notes: Hardware Dependent trigger settings are identical to the list items in the Trigger dialog.

D.11. D/A Device

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	NumberOfChannels		✓		integer	
instrument	*Ch#*.channel		✓	✓	string	ChannelNumber, "(None)"
instrument	*Ch#*.InactiveState		✓	✓	string	value, "HOLD"

D.12. Digital Out

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	NumberOfBits		✓		integer	
instrument	*Ch#*.channel		✓	✓	string	ChannelNumber, "(None)"
instrument	*Ch#*.InactiveState		✓	✓	string	"0", "1", "HOLD"

D.13. Analysis

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	FileNew	✓				
instrument	FileOpen,*filename*	✓				full path and file name
instrument	FileSave	✓				
instrument	FileSaveAs,*filename*	✓				full path and file name
instrument	FileClose	✓				
instrument	OptionsCheckNow	✓				
instrument	ActiveEquation		✓	✓	integer	
instrument	*Line#*.Comments		✓	✓	string	
instrument	*Line#*.Definition		✓	✓	string	
instrument	*Line#*.Label		✓	✓	string	
instrument	*Line#*.Units		✓	✓	string	
instrument	OptionsResultOn		✓	✓	string	"Left", "Right"
instrument	OptionsAutoCheck		✓	✓	string	"On", "Off"
instrument	*ResultLetter*.Label		✓	✓	string	
instrument	*ResultLetter*.Units		✓	✓	string	

D.14. Command

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	FileNew	✓				
instrument	FileOpen,*filename*	✓				full path and file name
instrument	FileSave	✓				
instrument	FileSaveAs,*filename*	✓				full path and file name
instrument	FileClose	✓				
instrument	OptionsCheckNow	✓				
instrument	ActiveEquation		✓	✓	integer	
instrument	*Line#*.Definition		✓	✓	string	
instrument	*Line#*.Active		✓	✓	string	"Yes", "No"
instrument	OptionsAutoIndent		✓	✓	string	"On", "Off"
instrument	OptionsAutoCase		✓	✓	string	"On", "Off"
instrument	OptionsAutoCheck		✓	✓	string	"On", "Off"
instrument	DecisionRate		✓	✓	single	
instrument	*Line#*.VariableName		✓	✓	string	Replace *Line#* with Command Settings table row number
instrument	*Line#*.InitialValue		✓	✓	single	

D.15. FFT

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	FileNew	✓				
instrument	FileOpen,*filename*	✓				full path and file name
instrument	FileSave	✓				
instrument	FileSaveAs,*filename*	✓				full path and file name
instrument	FileClose	✓				
instrument	*Line#*.Ch		✓	✓	string	valid channel number, "(None)"
instrument	*Line#*.Function		✓	✓	string	
instrument	*Line#*.Op1		✓	✓	string	Numerator
instrument	*Line#*.Op2		✓	✓	string	Denominator
instrument	*Line#*.WindowType		✓	✓	string	
instrument	*Line#*.Width		✓	✓	integer	
instrument	*Line#*.StartingPt		✓	✓	long int	
instrument	*Line#*.DC		✓	✓	string	"Yes", "No"
instrument	*Line#*.Avg		✓	✓	string	"Yes", "No"
instrument	*Line#*.Overlap		✓	✓	long int	
instrument	*Line#*.FramesToAvg		✓	✓	long int	

D.16. Relay

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	InitialState		✓	✓	string	"On", "Off"
instrument	DrivingChannel		✓	✓	string	channel number
instrument	Duration		✓	✓	single	number of seconds per frame
instrument	Points		✓	✓	long	number of points per frame
instrument	UseDefault		✓	✓	string	"Yes", "No"
instrument	StatusMessages		✓	✓	single	"Yes", "No"
instrument	ChannelList		✓	✓	integer	comma separated list of channel numbers
instrument	ToggleNow			✓		activates Relay element
instrument	Triggered		✓		string	"Yes" if Relay element is activated, "No" if it is not
instrument	TriggerPoint		✓		long	Point number where Relay element was last activated
instrument	TriggerType		✓	✓	string	"TriggerOnChannelValue", "DDECommand"
instrument	TriggerChannel		✓	✓	string	channel number
instrument	PreTriggering		✓	✓	string	"Yes", "No"
instrument	SpecifyAs		✓	✓	string	"Points", "Seconds", "PercentageFrameLength"
instrument	PreTriggerValue		✓	✓	single	
instrument	Condition		✓	✓	string	"Above", "Below", "Inside", "Outside", "PositiveSlope", "NegativeSlope"
instrument	Level		✓	✓	string	"One", "Two"
instrument	LevelOne		✓	✓	single	
instrument	LevelTwo		✓	✓	single	

D.17. Histogram

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	InputChannelType		✓	✓	string	"Time", "Frequency"
instrument	InputChannel		✓	✓	string	valid channel number, "(None)"
instrument	CalculationType		✓	✓	string	"Summing", "Averaging", "Counting"
instrument	Threshold		✓	✓	single	
instrument	OutputBin		✓	✓	string	"BandAnalysis", "Histogram"
instrument	BinWidth		✓	✓	single	
instrument	NumberOfBins		✓	✓	integer	
instrument	MaxLimit		✓	✓	single	
instrument	MinLimit		✓	✓	single	

D.18. MultiFrame

Topic	Item	Exec	Req	Poke	Format	Comments
instrument	InputChannelType		✓	✓	string	"Time", "Frequency"
instrument	InputChannel		✓	✓	string	valid channel number, "(None)"
instrument	FrameCalculationType		✓	✓	string	"Sum", "Average"
instrument	NumberOfFrames		✓	✓	long int	
instrument	OutputRate		✓	✓	integer	

Appendix E. PC Computer Information

Interrupts (IRQ)

The following table describes the standard PC interrupts, listed in order of priority. Check the documentation for your computer system and all add-in hardware to determine the available interrupts for your computer.

Priority	Interrupt	Typical Usage
1		Parity Error Detected
2	IRQ0	Interval Timer Output 0
3	IRQ1	Keyboard
	IRQ2	Interrupt for IRQ9 - IRQ15
4	IRQ8	Real-Time Clock
5	IRQ9	
6	IRQ10	
7	IRQ11	
8	IRQ12	
9	IRQ13	Math Coprocessor
10	IRQ14	Fixed Disk Drive Controller
11	IRQ15	
12	IRQ3	Serial ports COM2 and COM4
13	IRQ4	Serial ports COM1 and COM3
14	IRQ5	Parallel port LPT2
15	IRQ6	Floppy Disk Drive Controller
16	IRQ7	Parallel port LPT1

DMA Channels

The following table describes the standard usage for DMA channels in the PC. Check the documentation for your computer system and all add-in hardware to determine the available DMA channels for your computer.

Channel	Typical Usage
0	Unavailable on some PCs
1	
2	Floppy Disk Controller
3	XT only: Hard Disk Controller
4	Cascade for DMA channels 5 to 7
5	PS/2 only: Hard Disk Controller
6	
7	

Base Address

The following table describes the standard PC-AT base address usage (expressed as hexadecimal values). Check the documentation for your computer system and all add-in hardware to determine the available addresses for your computer.

Address Range	Typical Usage
200 to 20F	Game I/O (208 to 20F not used)
210 to 21F	Expansion Unit (218 to 21F not used)
220 to 22F	Reserved
230 to 23F	Reserved
240 to 24F	Reserved
250 to 25F	
260 to 26F	
270 to 27F	Parallel port LPT2 (270 to 277 not used)
280 to 28F	
290 to 29F	
2A0 to 2AF	
2B0 to 2BF	Alternate EGA/VGA adapter
2C0 to 2CF	Alternate EGA/VGA adapter
2D0 to 2DF	Alternate EGA/VGA adapter
2E0 to 2EF	Serial port COM4 (2E0 to 2E7 not used)
2F0 to 2FF	Serial port COM2 (2F0 to 2F7 Reserved)
300 to 31F	Prototype or network board
310 to 31F	Prototype or network board
320 to 32F	
330 to 33F	
340 to 34F	
350 to 35F	
360 to 36F	PC network
370 to 37F	Parallel port LPT1 (370 to 377 not used)
380 to 38F	SDLC, Bisynchronous communications (secondary)
390 to 39F	Cluster (394 to 39F not used)
3A0 to 3AF	Bisynchronous communications (primary)
3B0 to 3BF	Monochrome display and printer adapter
3C0 to 3CF	EGA/VGA adapter
3D0 to 3DF	CGA/MCGA adapter
3E0 to 3EF	Serial port COM3 (3E0 to 3E7 not used)
3F0 to 3FF	Floppy disk (3F0 to 3F7), Serial port COM1 (3F8 to 3FF)

Appendix X. Index

3

386MAX, 1-6

9

9513 Chip, 9-14

A

A/D, 2-11
A/D Demo, 2-20
A/D Device, 8-1; 8-13; 8-17; 11-4
A/D Overrun, 8-11
About Snap-Master, 1-6; 2-2; 2-10
Absolute, 12-13
Addition, 12-12
Admittance, 14-10
Aggregate Sampling Rate, 8-5
Aliasing, 3-4
Analog Input, 8-1
Analog Output, 11-1
Analog-to-Digital, 8-1
Analysis, 3-8; 3-10; 3-22
  Enhanced Syntax, 12-2; 12-7; 12-26
  Original Syntax, 12-2; 12-7; 12-23
  User Defined Functions, 12-27
ArcCosine, 12-14
ArcSine, 12-14
ArcTangent, 12-14
ASCII File Import, 4-4
ASCII Plotter Data Files, 4-1; 4-2; 4-4; 4-9; 4-21
Auto Layout, 3-3; 3-10; 3-20
Auto Power Spectral Density, 14-7
Auto Power Spectrum, 14-7
Auto Rescale, 3-2; 3-19
AUTOEXEC.BAT, 1-6; 1-8
Average, 12-16
  Running, 12-16

B

Bar Meter, 3-12
  Pictures, 3-13
Binary Plotter Data Files, 4-2; 4-22
Blackman
  Exact Blackman Window, 14-18
Blackman Window, 14-16
Blackman-Harris Window, 14-15; 14-16; 14-17
Block, 12-16; 12-17; 12-18; 12-23
  Overlap, 12-24
Block Mode, 6-11; 6-17
Block Size, 3-22
Bode Plots, 3-7
Bohman Window, 14-17
Boolean Operators
  And, 12-18
  Not, 12-19
  Or, 12-18
  Xor, 12-19; 13-6; 13-7
Buffer Retrace, 3-22
Buffers, 1-7; 2-8; 3-22
Bulk Modulus, 14-10

C

Cache, 1-8
Cauchy Window, 14-17
Channel Settings, 3-8; 3-24; 3-28
CJC, 15-8
Clipboard, 3-17; 6-1; 6-9
Clipbook, 6-1; 6-19
Coherence, 14-8; 14-36
Coherent Output Power, 14-9
Cold Junction Compensation, 15-8
Colors, 3-5; 3-26; 3-28
  Channel, 3-8
Comma Separated Variable. see CSV Data Files
Command, 2-11
Command Bar, 2-1
  Elements, 2-14
  Workspace, 2-4; 2-6; 14-1
Comment Field, 2-8
Comparison, 12-19
Complex Triggers, 8-8
Compliance, 14-10
Compression, 1-8
Conditional, 13-9
CONFIG.SYS, 1-6
Configuration, 8-12
Connecting Elements, 2-15
Control Panel, 2-6
Correlation, 12-16
Cosine, 12-13
  Inverse, 12-14
Cosine 4th Power Window, 14-18
Cosine Tapered Window, 14-18

Counter Timer, 2-11; 9-1
Gate, 9-14
Hold Register, 9-15
Internal Pacer, 9-12
Internal Pacing, 9-9
Load Register, 9-9; 9-15
Output, 9-15
Source, 9-3; 9-14
Cross Power Spectral Density, 14-8
Cross Power Spectrum, 14-8; 14-34
CSV Data Files, 4-1; 4-4; 4-9; 4-21
Cursor Anchors, 3-25
Cursor Cross Hair, 3-25
Cursor Data, 3-19; 3-25; 3-26
Location, 3-19
Cursor Data Hide, 3-22
Cursor Data Location, 3-22
Cursor Data Settings, 3-22
Cursors, 3-2; 3-3; 3-25; 3-38; 6-4
Cursors - Linked, 3-22; 3-25
Cursors - Secondary, 3-26
Cursors - Unplotted Channels, 3-26
Cursosr - Linked, 3-19

D

D/A Device, 11-1; 11-4
Data Pipes, 2-4
DDE, 6-1; 6-11; 6-14
Client, 6-2; 6-3; 6-5
Item, 6-2; 6-6
Link, 12-23
Links, 6-3; 12-26
Server, 6-2; 6-3; 6-5
Service Name, 6-2
Text Annotations, 3-27
Topic, 6-2; 6-6
DDE In, 2-11; 6-5
DDE Out, 2-12; 6-4; 6-8
Decision Rate, 13-3
Default Location, 3-10
Default Settings
Display, 2-19
DEFUSER (subdirectory), 4-13
Device, 2-21; 8-17; 11-2
Dial Meter, 3-14
Differentiation, 12-15
Digital In, 2-11; 8-13; 8-17; 8-21
Digital Meter, 3-10
Digital Out, 11-3; 11-7
Digital-to-Analog, 11-1
Disk In, 3-22; 4-4
Disk Out, 4-8
Save Options, 4-9
Display, 3-1; 6-4
Display Colors, 3-32
Display Defaults, 3-20
Display Layout, 3-23
Display Pages, 3-2; 3-24; 3-36
Division, 12-12
DMA, 1-7; 2-8
Dynamic Accelerance, 14-11
Dynamic Compressibility, 14-10
Dynamic Data Exchange. see DDE
Dynamic Flexibility, 14-10
Dynamic Inertia, 14-11
Dynamic Stiffness, 14-11

E

Element Letters, 2-3
Data Files, 4-3; 4-15; 4-16
Data Files, 4-4
Element List, 2-6
Elements, 2-10
EMM386, 1-6
Engineering Units, 7-1; 7-4
Enhanced Mode, 1-7; 8-11
Equation Builder, 12-5; 12-7; 12-29; 12-32; 12-34; 12-37; 12-40
Error Messages, 2-6
Event Counting, 2-11
Exact Blackman Window, 14-18
Excel, 6-11; 6-14
Exponential, 12-13
Exponential Data Files, 4-1; 4-2; 4-17
Exponential Window, 14-19
Extended Cosine Bell Window, 14-19

F

Fast Binary Data Files, 4-2; 4-11; 4-20
Fast Binary Format, 1-8
FBDF. see Fast Binary Data Files
FFT, 14-27; 14-29; 14-32; 14-34
Forward, 14-7
Inverse, 14-7
FFT - Noise Floor, 14-5
File Comments, 4-7; 4-10
File Names
Ordinary, 4-13
Fill Regions (Bar Meter), 3-13
Filter
FIR, 12-20
IIR, 12-21
IIR Family, 12-21
Smoothing, 15-12
Smoothing, 12-20
Windows, 12-21
Filters, 2-11
Find Time Of Event, 12-20; 12-23
Flat Top Window, 14-20
Fonts, 3-5
Fraction, 12-25
Frame Characteristics, 2-16; 12-9
Frame Length, 2-21; 2-22; 8-5; 12-26; 13-2
Frame Time, 12-22

Frames, 2-16; 2-21; 4-15
  Number Of, 2-21; 5-9
Frequency Analysis Module, 15-17; 15-22
Full Retrace, 3-22
Function Builder, 12-7
Function Defaults, 12-8

G

Gaussian Window, 14-20
General Analysis Module, 15-17; 15-22
Global Settings
  Workspace, 2-7
Grid Lines, 3-7

H

Half Cycle Sine Window, 14-20
Hamming Window, 14-21
Hann Window, 14-21
Hanning-Poisson Window, 14-21
Header, 4-1; 4-15
HIMEM.SYS, 1-6
Histogram, 2-11; 3-15; 15-17; 15-19

I

Icon Spacing, 2-6
If..Then..Else, 12-19
Impedance, 14-10
Indicators, 3-12
Input Ranges, 8-9
Installing Software, 1-6
Instrument Settings, 2-2
Instruments, 2-1; 2-3
Integration, 12-15
  Over A Range, 12-23
  X-Y, 12-16

K

Kaiser-Bessel Window, 14-22

L

Letter Remapping, 4-6
Linked Cursors, 3-19; 3-22; 3-25
Linked Zoom, 3-18; 3-23
Locked, 3-10
Log Plots, 3-3
Logarithm, 12-13

M

Macro, 12-41
Magnitude vs Freq, 3-9
Marker Settings, 3-26
Markers, 3-2; 3-3; 3-25; 3-38; 6-4
Maximum, 12-17
  Running, 12-17
Memory, 8-9; 12-8; 12-23
Military Time, 3-6
Minimum, 12-17
  Running, 12-17
Mobility, 14-11
Modulus, 12-25
MultiFrame, 2-11
Multiple Frame Calculations, 2-11; 15-15; 15-22; 15-23
Multiple Select Tables, 3-23
Multiplication, 12-12

N

Natural Antilog, 12-13
NetDDE, 6-7; 6-18
Network, 6-5; 6-7
Noise Floor, 14-5
Number Format
  Data Files, 4-9
Number Of Frames, 2-22; 8-6; 8-14; 9-7

O

Octave Band Analysis, 15-18
Online Help, 2-9
On-Screen Keypad, 12-6
Overplot, 3-21; 3-31
Overrun, 2-6
Oversampling, 12-10
Overwriting Data Files, 4-11

P

Pacing, 2-20
Panning, 3-2; 3-17
Parabolic Window, 14-22
PARADOX.NET, 7-7
Parzen Window, 14-22
Paste Link, 6-5; 6-9; 6-16; 6-17
Phase vs Freq, 3-9
Pi, 12-26
PID, 1-2
PID Control, 12-28
Pipe Mode, 2-2; 2-18
Plot Defaults, 3-3
Plot Settings, 3-24
Plot Templates, 3-3
Plot Title, 3-23
Plot Types, 3-3; 3-23
Plotting Techniques, 4-13
Poisson Window, 14-23
Power, 12-12
Pre-Triggering, 3-6; 4-17; 8-9
Printing, 3-2; 3-16; 3-17
Pulse, 12-26

Q

QEMM, 1-6
Quick Function Buttons, 12-5; 12-6

R

Range, 12-16; 12-17; 12-18; 12-22
Read Data Files. see Disk In
Rectangular Window, 14-15; 14-16; 14-23; 14-26
Registration, 1-3
Re-Letter Mode, 2-2; 2-5
Replay Options, 4-5
Retrace, 3-2; 3-20; 8-9
Retrace Mode, 3-22
Riemann Window, 14-23
RMS, 12-17
  Running, 12-17
Root Mean Square, 12-17
Round, 12-25
RS-232, 2-11; 8-17; 10-1
  Configuration, 10-7
  Delimiter, 10-5; 10-8
  Hydra Example, 10-8
  Initialization, 10-4
  Multiple Query, 10-2; 10-9
  Query, 10-4; 10-5; 10-9
  Response, 10-5
  Response, 10-9
  String Assignments, 10-3
  String Table, 10-4; 10-8
  Termination, 10-5
  Terminator, 10-8

S

Sample Instruments, 1-1
Sample Interval, 10-6; 10-9
Sample Rate, 2-16; 2-20; 2-22; 5-9; 8-5; 12-26
  Asynchronous, 8-4
Scatter Plots, 3-9
Scroll Bar, 3-2; 3-17
Secondary Cursors, 3-26
Sensor, 1-7; 2-11; 3-8; 3-10; 7-1; 7-7
  Automatic Calculation, 7-4; 7-8
  Database Configuration, 7-7
  Out Of Calibration, 7-3; 7-12
Sensor Assignments, 7-3; 7-11
Sensor Calibration History, 7-6
Sensor Specifications, 7-4; 7-8
SHARE.EXE, 1-7; 7-8; 7-10
Signal Conditioner, 2-11
Signal Conditioning, 7-1; 7-7
Sine, 12-13
  Inverse, 12-14
Sine 3rd Power Window, 14-24
Skip Rate, 3-26
Slope, 3-39; 12-15
SMARTDRV, 4-2; 4-11
Smooth, 2-11
SMSTART, 1-8
Snap-Calc, 12-4; 12-7
Spectral Analysis, 12-16
Spectral Lines, 14-25
Square Root, 12-13
Standard Binary Data Files, 4-2; 4-19
Standard Deviation, 12-18
Standard Mode, 1-7; 1-8
Start, 2-9
State Variables, 13-2; 13-4; 13-13
Stationary Plot, 3-6
Status Bar, 2-2; 13-8
  Elements, 2-14
  Workspace, 2-6
Status Log, 1-7; 2-2; 2-6; 2-8; 2-9; 2-21; 7-3; 8-11; 8-15; 8-20; 8-22; 10-6; 11-2; 11-7; 11-8; 13-11
Status Messages, 2-8; 2-21; 8-11; 11-2
Strip-Charts, 3-9; 3-32
Subroutines, 13-4; 13-12
Subtraction, 12-12
Support, 1-3
Sweep Graphs, 3-3; 3-6
Sweep Time, 2-21; 8-5
System Requirements, 1-5

T

Table
  Columns, 2-14
  Printing, 2-13
Tangent, 12-14
  Inverse, 12-14
TCLinear, 2-11
Temperature, 15-7
Templates, 3-3
Terminal Count, 9-4; 9-6; 9-14; 9-15
Text Annotations, 3-2; 3-27
Thermocouple, 2-11
Thermocouples, 15-7
Thickness, 3-29
Throughput Tester, 4-11
Tick Marks, 3-7
Time Function, 12-4
Time Of Day, 3-6
Time Shift, 12-22
Toolbox, 2-3; 2-6
Transfer Function, 14-9; 14-36
Transmissibility, 14-11
Triangular Window, 14-15; 14-16; 14-24
Trigger To Stop, 8-8; 15-2
Triggers, 8-15
  Bypass, 8-8
  Complex, 8-8
Truncate, 12-25

U

Undersampling, 12-10

V

Variance, 12-18

W

Wall Clock Time, 3-6
Wave Generator, 2-11
When, 12-20
Window Width, 14-24
Windows (FFT), 14-11; 14-24; 14-29
Windows 95, 1-8
Windows NT, 1-8
Workspace, 2-1; 13-8
Write Data Files. see Disk Out

X

X-Axis Label, 2-20; 5-9

Y

Y vs. X Plots, 3-9; 3-32
Y-Axis Settings, 3-7

Z

Z Transform, 12-22
Zoom, 3-2
Zoom - Linked, 3-18; 3-23
Zoom Out, 3-18